

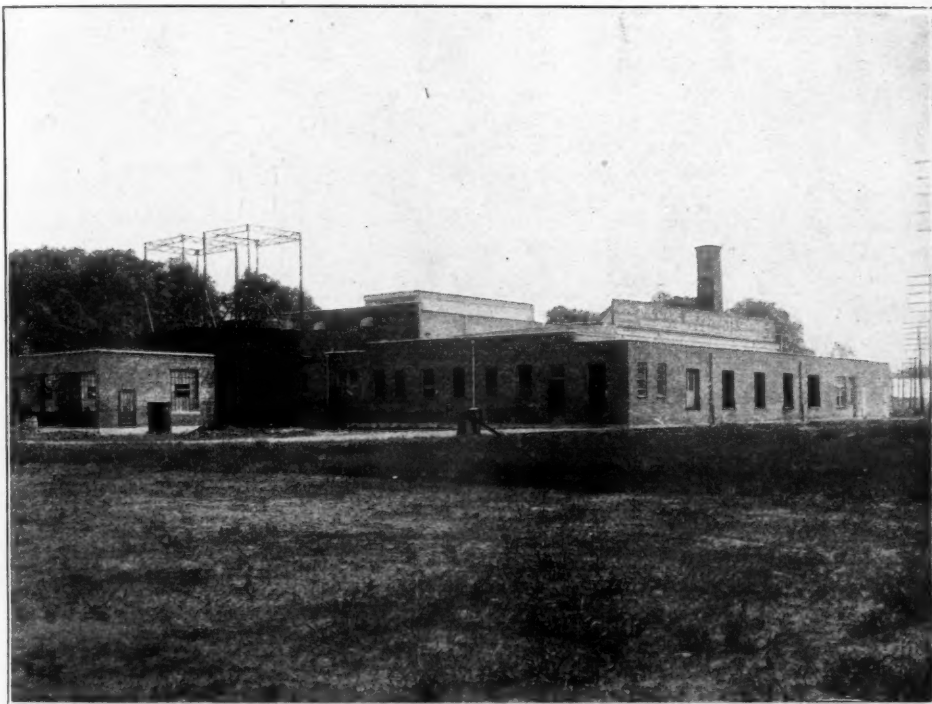
# COMPRESSED AIR

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PLANT OF THE LINDE AIR PRODUCTS COMPANY, ELIZABETH, N. J.

## AIR "ON A TEAR"

BY FRANK RICHARDS.

Probably few realize the rapid growth and the present magnitude of the oxygen industry in the United States. The Linde Air Products Company has a dozen plants, located in different parts of the country for convenience of distribution, operated chiefly for the production of oxygen directly from the atmosphere, and the two views here given represent the

"before and after" of one of these. The oxygen industry is not to be considered a dangerous one, and the company has never before had any such occurrence as it seems to come in the line of my duty here to describe. There were three fatalities in this case, and a rigid investigation was conducted by the local authorities, with the result that the Linde Company was exonerated from all blame in connection with the accident.

The plant shown in Fig. 1, known as No. 3,

of the Linde establishments, was located at Linden, near Elizabeth, N. J., and on Saturday evening, Aug. 15, it was totally destroyed by fire and explosion, three being instantly killed, the engineer in charge, a workman or helper and the little son of the engineer, and three or four injured. Fig. 2 speaks for itself as to the completeness of the destruction. The building was fireproof except the roof, which was of slow burning construction and the office partitions and furniture.

There was a five-stage compressor delivering air up to 1800 lb. and three compressing pumps working up to a similar pressure for charging the tanks with oxygen for shipment. Electric power from an outside source was used entirely for driving. No oil was used in the compressor cylinders, and it and the pumps spoken of, with their pipes and appurtenances were found intact except as damaged by the fire and the falling of the roof. The oxygen produced was stored in the large gas holders seen in Fig. 1 until charged into the tanks. It is conceded by all that nothing thus far spoken of here requires any further consideration when seeking the cause of the catastrophe.

The Linde process consists essentially in the liquefaction of air by arrangements which have been frequently and sufficiently described, and then the separation of the nitrogen and the oxygen by the successive evaporation of each from the liquid. These operations, however, are not conducted separately, but more or less simultaneously and continuously with the liquefaction, and as a consequence the special apparatus employed, technically known as the "rectifier," is a very complicated affair, and the proper control and manipulation of it are among the most exacting of technical responsibilities.

In "Richards' Compressed Air Practice," recently published, the last chapter contains a diagrammatic sketch of a rectifier, and at the close of a condensed description it is remarked: "One may well wonder and inquire how the man in charge of the apparatus can keep himself informed as to all that is going on within it, throughout the series of operations, even when everything is going well; and especially how he can discover when things are going wrong or determine what he should do to right them." It would seem, as will appear later, that the engineer who was killed

was in this conglomeration of perplexity when the catastrophe occurred.

#### WHAT CAUSED THE ACCIDENT?

As to the sequence of events in the development of this catastrophe no one seems to be quite clear. Indeed, it has not been decided whether there was first of all an explosion and then the fire, or whether fire, an actual ignition, was the beginning of it all. At the coroner's investigation the principal inquiry was as to how an igniting spark or flame could have been communicated to the explosive mixture or assemblage of combustible ingredients assumed to be present and which it would have been possible to fire in this way. There were no open lights, all the light being furnished by incandescent lamps with guarded bulbs.

It is understood that while the representatives of the Linde Company candidly state that they are unable to explain the accident, their principal speculation also has been as to how fire could have been first communicated. This being so, it would seem to be quite in order, and more than desirable, that suggestions should be submitted, and what follows is nothing more than such a suggestion of a possible explanation.

#### LIQUID AIR PHENOMENA.

It is necessary for us to note in the first place how closely, in many of their characteristics, air and its liquid resemble steam and water. Both are readily convertible, or in fact change of themselves, from the liquid to the gaseous state, or vice versa, whenever the conditions of pressure and of temperature are right for such a change. There is no coaxing about the operation, the change being inevitable when the compelling conditions concur.

Water, as we all know, boils under atmospheric pressure at 212 degrees Fahr., and is changed to vapor as rapidly as the water can be brought to that temperature. To convert a considerable body of water into vapor sufficient heat must be artificially provided. To raise the boiling point of water it must be confined, and its vapor prevented from escaping, until the required temperature and the higher pressure are obtained. In the case of converting water into steam there is thus something to be actually done by us in providing the necessary increase of temperature.

With air the practical conditions are reversed. Air, the liquid, when under atmospheric pressure boils at—312 degrees, or 524



AFTER THE FIRE.

degrees below the boiling point of water. This temperature is so low that the great problem in handling liquid air for any purpose after it is produced is to keep its temperature down. If liquid air is confined and allowed merely to be heated by the absorption of heat from the container and its surroundings until it is up to normal atmospheric temperature the pressure will be about 12,000 lb. per sq. in., or say 100 times the gage pressure at which old steam boilers have been in the habit of exploding. Of course explosion would usually occur long before this high pressure was attained.

We happily do not know much from experience about liquid air explosions, because we know too well that the liquid must not be confined. It is worth while, however, to note the phenomena which might be expected to occur in the case of such an explosion. It would be quite analogous to the explosion of a steam boiler, except in one particular.

The difference in destructive effect between the explosion of an ordinary compressed air receiver and that of a steam boiler of comparable size and pressure has been often noted, the

latter being always much the more violent. In the case of the air receiver there is nothing but the volume of air confined in the receiver to be reckoned with, even this air losing some of its explosive force by the fall of temperature in the act of expansion. With the steam boiler however, there is not only the actual body of confined steam to escape, but this is followed by mere steam instantly generated from the body of hot water, this continuing and following up the original body of steam until the temperature of the water has fallen to the normal atmospheric boiling point. In a boiler with any considerable water space only a portion of the water would thus flash into steam upon release of pressure, as its temperature would fall so rapidly in supplying the latent heat to the steam that might be generated. The entire operation would occur at temperatures above that of the atmosphere, so that the cooling of the water would be hastened and the generation of the follow-up steam would be thereby retarded and finally stopped.

In the case of an explosion of confined liquid air there would be not only the expansive

force of the actual air in the upper portion of the containing vessel but there would be the same follow-up pressure from the air which instantly would boil away from the liquid, and all of the liquid would be very quickly vaporized, because the temperature of its surroundings would be so much higher than its boiling point. An explosion of confined air and its liquid should thus be expected to be more violent than an explosion of steam and water.

Supplementing the work of the air compressor, the apparatus employed for the liquefaction of the air and the separation of the two principal gases, the rectifier as it is technically called, is a very ingeniously complicated affair, its construction in detail and the processes employed in its manipulation being covered by patents in this and other countries, in addition to which experience and continued operation have added many valuable details, so that, very properly, the Linde Company do not reveal these things promiscuously, and we can only speak in a general way as to what happened in this case.

We know that the initial trouble was at the rectifier, as things were going wrong there. The compressor had been stopped and the engineer was making an investigation. The compressor supplied the air to the rectifier at a pressure from 1500 to 1800 lbs., this pressure being maintained in certain parts of the apparatus, while in other parts expansions occurred as an essential part of the operation. When in full operation there is quite a body of liquid air in process of supplementary treatment, and it goes without saying that intense cold prevailed within, there being large masses of wool packed between an inner and an outer shell, its function in this case being to keep heat out instead of keeping it in, which would have been the use of it with which we are more familiar.

A door of the outer shell was removed, the wool inside was pulled out and then the door of the inner shell was taken off, the effect of this, remembering the liquid air within, being equivalent to the firing up of a steam boiler. An investigation of the interior was now attempted. The moisture in the immediately surrounding air was condensed, causing a thick fog, and the first man to look in quickly gave it up on account of the cold. Then the engineer tried it, he apparently reaching farther in, so that he exclaimed "I think I've found the

leak," and immediately the catastrophe occurred. Besides the three who were killed, two men were thrown out through the windows, and they with two or three others in remoter parts of the building were so stunned that no one can tell anything further as to what happened.

The explosion and the beginning of the fire, so far as appears, were practically simultaneous. If there was first an explosion of the confined liquid air subject to abnormal pressure by accidental stoppage of passages, by a mistake in the manipulation of stop valves, or by the failure of pressure releasing devices, such an explosion, accompanied by the breaking of incandescent lamp bulbs, might easily account for the fire, as ignitions from this cause are a well known possibility in the gaseous atmosphere of coal mines.

The destruction of the building by fire was apparently as complete as was ever recorded. The fire was undoubtedly intensified by the oxygen released from the great number of charged tanks, all of which were emptied while the fire was in progress. These tanks had different ways of discharging their contents when exposed to the heat. There were 123 low pressure tanks or cylinders of an old type used by another company and now being discarded. These were charged to a pressure of only 300 lbs. but 5 of these cylinders opened at the sides and 22 had their brazed heads blown out. There were also 4 high pressure 50 ft. cylinders of German make belonging to customers which also let go. The metal of all the cylinders which gave out was excellent and without brittleness, so that there were no detached pieces thrown off in any case.

#### THE SAFETY TANKS.

Notwithstanding the severe loss sustained by the company there is a large compensation in the revelation of the absolute safety of the high pressure tanks now employed by the company and sent out by them all over the country. Probably no severer test of them could have been devised. There were in the building 792 of these high pressure tanks, such as seen in Fig. 2, charged to 1800 lbs. and not one of these exploded, although all of them when heated discharged their contents and were relieved of all pressure.

The safety device employed is simple enough. There is a fusible plug supporting a copper disc. The plug melts at a precisely determined temperature, which is not high, and

this melting removes the support from the copper disc and the contents of the tank are immediately released. This safety device did not fail to operate in any one of the 792 cylinders exposed to the intense and sudden heat.

Although the destruction of the plant was so complete it is being built again with great rapidity, so that it is expected that operations will be resumed by Dec. 1, which indicates, by the way, what a demand there is for the product.

#### COMPRESSED AIR FOR ORE FLOTATION

New methods of accomplishing ore flotation are being rapidly developed, and a wide variety of means used to accomplish the purpose. One of the most interesting as well as successful methods is that of using air as the agitating and froth-producing medium. Plants using this method have been installed by the General Engineering Co., of Salt Lake City, Utah, at the National mill, in Idaho, the Magma, Miami and Inspiration in Arizona. The ore is mixed with oil and water and fed into a separator which consists of a rectangular cell having an inclined false bottom covered with fabric. Compressed air admitted into compartments below the false bottom passes upward through the fabric and is divided into innumerable small bubbles which form a froth 12 to 18 inches deep in the cell. Mineral concentrate rises with this froth and overflows the sides of the cell, while gangue flows down the inclined bottom and is discharged. If desired, the first cell can be used as a rough concentrator, and the valuable product re-treated in another cell. The products from several roughers could be combined on one cleaner. Pine oil has been found to be a good floating medium, and is used in the oil mixture in varying proportions.—*Metallurgical and Chemical Engineering.*

#### AUTOMOBILE SPEED RECORD—WIND RESISTANCE

On August 12th, Teddy Tetzlaff in a Blitzen-Benz automobile, raced over the Salt Beds at Saduro, Utah, on the Western Pacific Railway, 112 miles west of Salt Lake City, at a speed of 142.85 miles per hour, or 2.38 miles per minute. This speed was attained in demonstrating the theory that these remarkable beds of salt offer the fastest course in the world. These salt beds 65 miles long and 8 miles wide, and, except for the railroad crossing them, are

believed to be the greatest ever attained by man and can only be accounted for by the non-resistance and the low temperature of the crystallized salt, which forms a hard and absolutely level surface and one which even in the hottest weather does not heat the tires.

For speed records there is, besides the condition of the road surface, the resistance of the atmosphere to be reckoned with, and at such unheard of speeds as the above this resistance may be greatest of the obstacles to be overcome, and the one which must eventually determine the ultimate limit.

The simplified formula of the U. S. Weather Bureau for computing wind pressures against perpendicular area 1 foot square, with barometer at 30 inches, is  $0.004V^2$ ,  $V$  being the velocity in miles per hour. In the case above  $.004(142.85^2) = 41.624$  lb. per sq. ft., and if we assume the auto to present an effective resistance area of only 8 sq. ft. the total resistance would be  $41.624 \times 8 = 333$  lb. The speed attained, 2.38 miles per min.  $= 12566$  ft. per min., and this multiplied by  $333 = 4184478$  ft. pds. per min., and this divided by  $33,000 = 126.8$  horse power.

#### INFLAMMATION LIMITS OF GASEOUS MIXTURES

It is interesting to note that British investigators have proved conclusively that minute sparks can be passed through an explosive gaseous mixture without exploding it, although the temperature of the spark is above the generally accepted ignition temperature of the mixture. It was observed, however, that some slight combustion took place in the path of the spark. When the intensity of the spark was increased, the gases exploded.

These experiments would seem to indicate that gas mixtures differ considerably in their ignition temperature. In other words, a gaseous mixture diluted with inert gas, or under reduced pressure, requires a hotter spark to fire it than when it exists under normal conditions. Methane (the chief constituent of fire-damp) differs from hydrogen in having a higher ignition temperature and a more prolonged process of oxidation for complete combustion. It is for this reason, in all probability, that in the case of an inflammable mixture containing methane, the source of heat necessary to inflame the mixture must be more intense and must be longer in contact with it than in the case of a hydrogen mixture.—*Coal Age.*

## THE LEYNER MACHINE FOR DRIFT ROUNDS

BY CHARLES A. HIRSCHBERG.

Economical mining and tunneling calls for the breaking of the most ground with the least footage of holes, inasmuch as this means a saving of powder, time, labor, materials and power. To accomplish this, a thorough knowledge is necessary of the character of the ground to be drilled and broken, its hardness and stratification, whether damp or dry and whether likely to cave or not. Drill steel properly gaged and bitted must be provided, and drilling machines that are economical of power, easily maintained, quickly handled and capable of rapid drilling. Some types of machine drills, while having a large capacity for work when no limitations are imposed as to location, size and depth of holes, cannot always be utilized for drilling the most effective round of holes, due to various features of design to be enlarged upon later.

These features cannot be categorized with faulty design, in the true sense, but rather should be considered as limitations that render an otherwise efficient machine unsuitable for certain rounds of holes calling for drilling close to the top or side walls and at a slight pitch; such machines require ample head and wall room for operation; consequently they are slow in operation and hard to handle.

These drills are of the piston or reciprocating type, as distinguished from the hammer drill. Although all hard-rock drills are reciprocating machines, strictly speaking, the term is best applied to that type in which the steel is rigidly fastened to the front end of the piston and reciprocates back and forth with it, while the term "hammer" is applied to that type in which the steel is inserted loosely in the front end of the machine and is struck by the piston.

The hammer drill divides itself into several styles as distinguished by the method of application to the rock. First, the mounted type, of which the Leyner is an example; second, the self-supporting and automatic air-feed type, commonly called a stoper; and third, the held-in-the-hand plugger or sinker type.

It is the purpose of this paper to deal more particularly with the mounted-hammer type in describing drilling rounds for different characters of ground, and it will be brought out that reciprocating drills are restricted in their application to certain drilling rounds, and ham-

mer drills, on the contrary, are readily applicable to the drilling of all kinds of rounds. It is between these two types alone that a true comparison can be made, inasmuch as both are applied to similar work, such as drifting or tunneling, whereas the stoper and the plugger only rarely come into competition with the mounted machines.

### THE LEYNER CUT.

Fig. 1 shows a round of holes, to which the term "Leyner cut" has been applied, used in a drift or tunnel where the rock is extremely hard. It has been used with variations in the mines of Arizona, Colorado and Michigan. It involves a pyramid or center cut including a great many upper or dry holes.

The advantages of the Leyner cut are: (1) The holes are drilled with as few changes of machines and set-ups as possible; (2) a pyramid-shaped wedge of rock is first pulled from the center, after which the rest of the round breaks readily. While there is no hard-and-fast method of putting in such a round of holes, the principle is the same in all cases and involves the many upper and dry holes shown in the illustration.

It is particularly suitable for solid formations containing no slips or seams to break to. It has been used with marked success in the hard rock and ore of northern Michigan, and in at least one case has resulted in drifting at nearly four times the speed formerly made with piston machines. The object of the cut and the system of putting in the holes have been found capable of easy explanation to the foreign miners, so that in a short time they were taught to use this round successfully and almost automatically.

Referring to the illustration, *C* designates the position of the crank of the drill in each case. *A* is a cross-bar in the first position. From the top of the bar the four back holes, Nos. 9, 10, 11 and 12, are drilled. The machine is then "dumped" or tipped forward until the crank can just turn and clear the back or top of the drift, is moved out a little on the bar and the top centercut holes 1 and 2 are drilled. If the bar is set up correctly in a drift of the size shown, the machine can be dumped enough to reach the center of the drift heading with the bottom of the hole. The machine is then turned under the bar and the side holes 7 and 8 and the cut holes 5 and 6 are drilled.

The crossbar is next dropped to position *B*, the machine is set up on top and the side holes

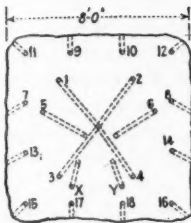


FIG. 1

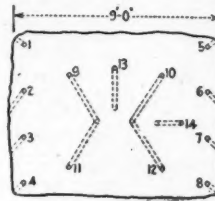
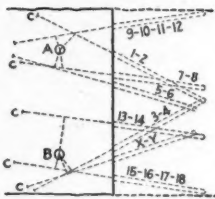


FIG. 3.

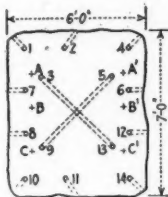
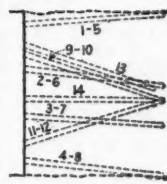


FIG. 2

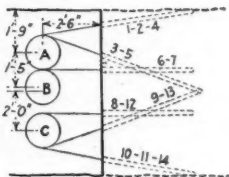


FIG. 4.

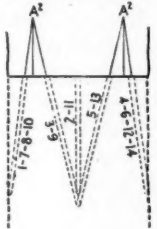
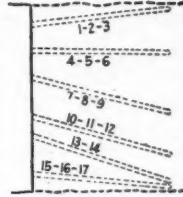


FIG. 5.

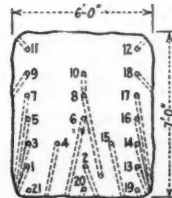
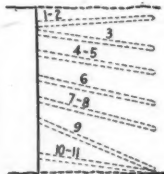


FIG. 8.

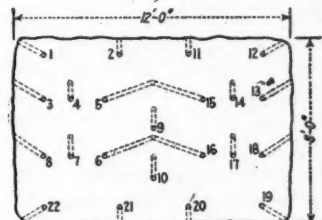
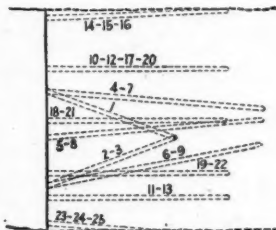
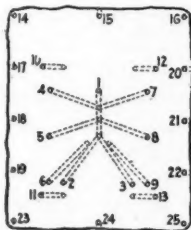
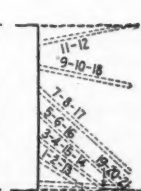


FIG. 9.

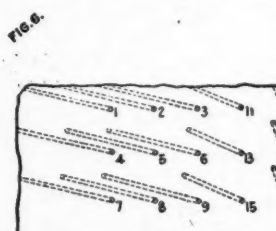
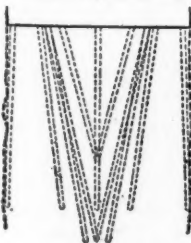


FIG. 7.

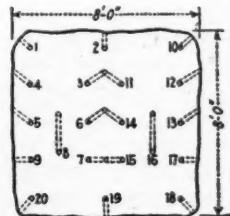


FIG. 10.

VARIOUS LAYOUTS OF HOLES WITH LEYNER DRILL.

13 and 14 drilled. Finally, the machines are turned under the bar, tipped up in front so that the crank just clears the bottom of the drift and holes 3 and 4 are drilled so as about to meet Nos. 1 and 2 in the center of the heading. The four lifters, 15, 16, 17 and 18 are drilled last, except that, if there is time enough, relievers something like X and Y may be put in to make sure. When sufficiently strong explosive is used, however, the round will break without these last.

Some of the holes could be placed to better advantage, perhaps if there were time for another "set-up," or if a column could be used, but this particular sketch applies to a place where it was necessary to drill 100 ft. with two machines in extremely hard steel-ore and jasper and there was no time to waste.

The full round shown in the illustration is designed for hard rock, but a modified round of this kind could be used almost anywhere. In softer and better breaking ground, cut holes 5 and 6, relievers X and Y, one lifter and one back hole can be left out, but the four cut-holes 1, 2, 3 and 4 are nearly always used and are pitched up or down, and in, to meet about at the center.

There are two reasons why this round is practically impossible with piston drills. First, they cannot drill it fast enough, particularly on account of the dry holes; and second, the size of the piston drill is too great to permit operating it in the positions necessary to give the holes the proper pitch and angle.

Fig. 2 shows another pyramid cut as used in some of the mines of Mexico for driving small drifts in hard rock. This round is drilled from an arm mounted on a column, A and C, A' and C' representing the vertical positions of the arm, and A" the horizontal position of the arm and drill on both sides of the column; the column is placed midway between the walls of the drift. Holes 4 and 5 are first drilled from the top of the arm, on the right-hand set-up. The drill is then swung under the arm and hole 6 put in. Next the arm is swung to the left-hand side of the column and hole 7 drilled. The machine is turned to the top of the arm and holes 1, 2 and 3 are drilled. The arm and drill are then dropped to C and hole 8 drilled; the machine is swung under and 9, 10 and 11 put in. Holes 13 and 14 are drilled by swinging the arm and drill to the right of the column with the machine underneath. The

machine is turned on top of the arm and hole, 12 drilled, which completes the round.

#### A SOUTH AFRICAN ROUND.

Fig. 3 shows a round of holes employed in the mines of South Africa in a drift 9 ft. wide by 7 ft. high. It usually comprises 12 holes. Hole No. 13 is sometimes drilled when the rock is not breaking properly, while both 13 and 14 are used when extremely hard rock is encountered.

For extremely hard ground extra holes may be drilled with the arm and machine at B, but in all moderately hard rock this has not been found necessary.

The distance between holes 1, 2, 3 and 4 in the vertical line is approximately 2 ft., likewise the distance between holes Nos. 5, 6, 7 and 8. Holes 9, 10, 11 and 12, or, in other words, the cut holes, are put in approximately 4 ft. apart at the face of the rock, but holes 9 and 10 slant downward and inward and meet holes 11 and 12, which slant upward and inward. The distance between the junction of holes 9 and 11, and 10 and 12, at the bottom, is approximately 18 in. Hole 13, when used, is put in 1½ ft. below the top of the drift and slanting downward until it comes to about a central point 18 in. from the junction of holes 9 and 11 and from that of 10 and 12.

Hole No. 14, when used, is put in at the face, about 2 ft. 6 in. from the center of the cut, and slants in as shown, to a distance of about 18 in. from the junction of holes 10 and 12. Usually, however, holes Nos. 13 and 14 are not used. The round of 12 holes generally breaks between 5½ and 6 ft. of ground. The machine is mounted on a column and arm.

#### CRIPPLE CREEK ROUNDS.

Fig. 4 shows a hammer-drill round used in the Cripple Creek district of Colorado. It consists of 17 holes and is used only in drifts 8 ft. high by 6 ft. wide or larger, where the rock is an exceedingly hard phonolite. It will be noted that with the exception of the back holes 1, 2 and 3, all the holes point downward. This round will break between 5 and 6 ft. of ground.

Fig 5 shows the round of Fig. 4, modified for a smaller drift, one 7 ft. high and 5 ft. wide. It consists of but 11 holes and is used for drilling in brecciated formation and in vein matter.

The ordinary double-screw column with one set-up is used for both rounds. Of course, the

arm is shifted from side to side and lowered as occasion requires, the holes being drilled from both above and below the arm.

These rounds are varied slightly with the nature of the ground; fewer holes are sometimes drilled, but never more.

#### THE LUCANIA TUNNEL.

Fig. 6 illustrates a round used several years ago in driving the Lucania tunnel at Idaho Springs, Colo., put in with Leyner machines. This tunnel is 9 ft. 6 in. high by 8 ft. wide, and the advance averaged between 7 ft. 6 in. and 8 ft. per round.

The set-up involved the use of two columns, one carrying two arms and the other one arm, making a total of three machines. Short cut-holes 1, 2 and 3 were drilled 6 ft. deep; long cut-holes 4, 5, 6, 7, 8 and 9, 9 ft. 6 in. deep; relievers 10, 11, 12 and 13, 8 ft. deep; back holes 14, 15 and 16, 8 ft. deep; side holes 17, 18, 19, 20, 21 and 22, 8 ft. deep; lifters 23, 24 and 25, 8 ft. deep. Holes 6, 2, 3, 9, 11, 13, 23, 24 and 25 were drilled by the bottom machine;

the rest were drilled by the two top machines. The round was shot in the order numbered, the two cuts being loaded and fired first. The balance of the round was then loaded and fired.

During 1911, when the tunnel was being driven on contract by Claypole & Hauser, the work was remarkable for rapid progress and low costs. During June of that year a careful record was kept of all expenditures, and it was found that the tunnel was being driven its entire cross-section for \$15.93 per ft. This figure included everything but depreciation on the power plant, i.e., compressor and blower, which was furnished by the Lucania Co.

The figures for the month of June follow:

#### MICHIGAN COPPER ROUNDS.

Fig. 7 exhibits a round employed in the Michigan copper country for what is known as drift stope, the width of which varies according to the width of the lode; the object is to take out all of the rock between the foot and hanging walls, the holes being point-

#### JUNE PERFORMANCE AT THE LUCANIA TUNNEL

Nature of ground—hard pegmatite.  
Total progress—232.5 ft.  
Number of shifts—30 eight-hour shifts.  
Advance per shift—7.75 ft.  
Drill labor—3 runners and 2 helpers.  
Outside labor—1 trapper, 1 trackman, 1 blacksmith and 1 day and 1 night engineer.  
Mucking—contracted at \$2.65 per linear ft.  
Machines used—three water Leyner drills.  
Depth of holes—6 ft., 8 ft. and 9 ft.  
Powder—1½-in. du Pont 50% Repauno, German ZL fuse and 6X du Pont caps  
Outside equipment—Leyner 480-ft. belted air compressor, Leyner drill sharpener and Connersville blower.

#### COST DISTRIBUTION

Classification	Labor	Live Stock	Material and Supplies	Freight and Handling	Total	Per Ft.
Superintending.....	\$150.00				\$150.00	\$0.6451
Engineers.....	240.00				240.00	1.0322
Excavation <sup>1</sup> .....	480.00		\$1056.61	\$43.21	1579.82	6.7949
Day tramping <sup>2</sup> .....	105.00	\$12.75			117.75	0.5064
Track.....	105.00		11.87	0.49	117.36	0.5048
Blacksmith.....	150.00		16.80	0.70	167.50	0.7204
Mucking.....					616.12	2.6499
Power.....					515.86	2.2187
Lighting.....			14.85	0.60	15.45	0.0664
Drill repairs.....					21.30	0.0916
Miscellaneous supplies.....			159.40	5.08	164.48	0.7074
Totals.....	\$1230.00	\$12.75	\$1259.53	\$50.08	\$3705.64	\$15.93+

<sup>1</sup> Includes all steel received to that date.

<sup>2</sup> For handling supplies, etc., owing to the mucking being done on subcontract.

#### COST RECAPITULATION

Classification	Total	Per Ft.
Labor.....	\$1230.00	\$5.2963
Live stock.....	12.75	0.0548
Material and supplies.....	1259.53	5.4137
Drill repairs.....	21.30	0.0916
Freight and handling.....	50.08	0.2137
Mucking.....	616.12	2.6499
Power.....	515.86	2.2187
Total.....	\$3705.64	\$15.93+

ed in some cases toward the foot and in others toward the hanging. The round as illustrated would do for an 8x14-ft. drift. The set-up consists of a double-screw column with arm.

Fig. 8 shows the method in use at the Quincy mine for small drifts; it works satisfactorily in this particular case owing to the fact that driving is done entirely through trap, there being no copper to contend with. This round is not good, however, in ground that is heavily charged with copper, since great difficulty would be encountered in getting the cuttings out of the holes. In such cases the direction of the holes should be reversed so as to point upwards. The round is shown for a 6x7-ft. drift and is drilled from a column with arm.

The holes are drilled to the following depths: 1, 2 and 3, 2 ft. 6 in. deep; 3, 4, 14 and 15, 3 ft. 6 in. deep; 19, 20 and 21, 4 ft. deep; 5, 6 and 16, 4 ft. 6 in. deep; 9, 10, 11, 12 and 18, 5 ft. 8 in. deep; 7, 8 and 17, 6 ft. deep.

#### MICHIGAN IRON ROUNDS.

In Fig. 9 is shown a round of holes for an 8x12-ft. drift as used in the Dober mine near Iron River. The ground was a gray slate. The holes were drilled from a column and arm and required two set-ups, owing to the wideness of the drift. All holes were drilled to a depth of 5 ft. with the exception of those numbered 5, 6, 13 and 16, which were drilled 5 ft. 6 in. deep.

Fig. 10 shows a round of holes employed in medium-hard iron ore at the Cary mine, Hurley, Wis. The size of the drift is 8x8 ft.

All holes with the exception of 18, 19 and 20 look up a little above the horizontal. Holes 1, 2, 4, 5, 9, 10, 12, 13 and 17 are drilled 5 ft. deep; 18, 19 and 20, 5 ft. 6 in. deep; 3, 6, 7, 11, 14 and 15, 5 ft. 8 in. deep; 8 and 16, 6 ft. 6 in. deep. This cut breaks well and lengthens the drift  $4\frac{1}{2}$  ft. with each round. The round is drilled with column and arm set-up.

#### THE ROOSEVELT TUNNEL.

The Roosevelt drainage tunnel at Cripple Creek, Colo., is believed to have been about the hardest tunnel driving ever encountered. Three sets of contractors successively undertook the job and failed. The rock is that designated by the government geologists as Pike's Peak granite. In some parts the rock has a gneissic or schistose structure, but in the main it is characterized and made notorious by the lack of seams or joints. Thus, while the rock itself is hard, the lack of lines of fracture and planes of seaming is doubtless

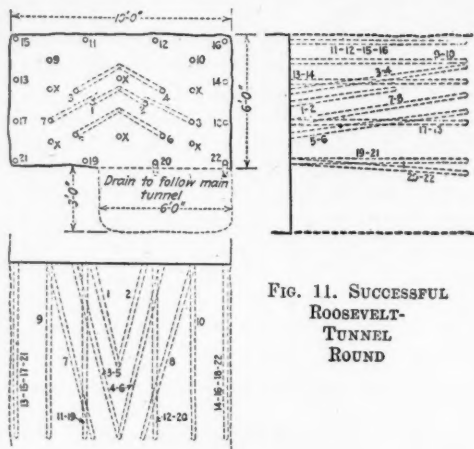


FIG. 11. SUCCESSFUL ROOSEVELT-TUNNEL ROUND

responsible for the poor rate of progress made by the first contractors. The tunnel was started 10 ft. high and 7 ft. wide, but in the final contract this was changed to 10 ft. wide by 6 ft. high over the rails, and a 3x6-ft. drainage ditch was added.

After the trial of several systems of placing the drill holes, that shown in Fig. 11 finally proved to be best adapted to the tough nature of the jointless rock. Water-Leyner drills were employed. In attacking the ordinary rock, all holes were drilled 8 ft. except the cuts and relief cuts, Nos. 1 to 8, inclusive, which were drilled to a 10-ft. depth. In tougher ground, these depths were each cut down 2 ft., and in addition to the 22 holes used on the ordinary rock and numbered in Fig. 11, the six extra holes X were put in.

At first, even with the use of from 300 to 350 lb. of 60 per cent. dynamite, great difficulty was experienced in properly blasting the eight cut-holes, sometimes several loadings being necessary to blow out the cut. Finally, however, after putting in the two extra cuts shown, even the toughest ground yielded. The system of placing the holes was evolved with a view not only to blasting the rock to the best advantage, but also to allow the greatest economy of time in drilling. These ends proved to be best effected by mounting the two Leyner drills on a single, horizontal crossbar, instead of on the more usual two independent vertical columns. In this way even the maximum number of 28 holes required but two set-ups of the bar. It will be readily understood that this way of placing the bar eliminated the necessity of mucking out of the bottom before starting drilling, as when vertical columns are used.

The grade line was carried about 18 in. below the top of the bore and about 8 to 12 in. below this was placed the bar. From this, the center and corner back-holes were drilled, and then by revolving the drill around and beneath the supporting bar, all of the remaining holes except the center lifters and bottom corners were put in.

It will be understood that the difference in the level of the drill bit between its position on top of the bar, and below the bar, amounted to about 2 ft. By using proper judgment in placing the horizontal bar, therefore, the feat of putting in 18 holes from one set-up was easily accomplished. The bar was then shifted to its second position, usually about 18 to 24 in. above the floor, and the last four holes put in. In tough ground an extra center-cut hole X was also put in from this set-up.

The bits used at the start of a hole were 3 ft. in length, with a diameter of  $2\frac{3}{4}$  in. Each succeeding steel was 2 ft. longer than the one before, the 11-ft. cut holes requiring six steels to a hole, while the others required five steels each. The diameter of the hole bottom averaged about  $1\frac{1}{2}$  in. The number of steels was carefully determined so that as fast as one became dulled it was replaced by a sharp one. While this may seem a minor point, experience proved it to be a potent factor in influencing the speed of drilling and increasing the rate of progress made in driving the tunnel.

The ditch was kept back of the breast about 150 ft. and taken out at convenient intervals by placing vertical 3-ft. holes spaced on 2-ft. centers along the intended center line of the ditch, an ordinary tripod being employed for this work.

#### THE LARAMIE-POUDRE TUNNEL.

The Laramie-Poudre tunnel at the beginning of the year 1911 held the best two American tunnel-driving records: 609 ft. in January, 1911, and 653 ft. in March. Fig. 12 shows the layout of the holes in regular work. The holes were drilled and shot in the succession numbered in the cut, requiring two set-ups of the tunnel bar, no column being used. The upper set-up was drilled on top of the muck pile, and in the meantime the muck was cleared away, when the bar was lowered and the lifters put in. Holes were started  $2\frac{1}{8}$  in. in diameter and bottomed at  $1\frac{3}{8}$  in.

Two water Leyner machines were used, drilling 10-ft. and 12-ft. holes. In case of extreme-

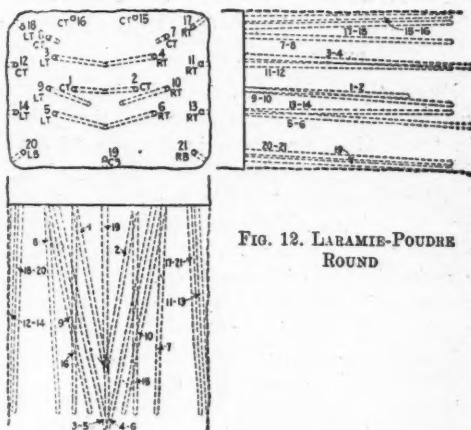


FIG. 12. LARAMIE-POUDRE ROUND

ly hard rock a third machine was mounted, each machine drilling holes as follows: Those lettered *LT* were drilled by the left-hand machine on the top set-up, those marked *CT* by the center machine on the top set-up, and those marked *RT* by the right-hand machine on the top set-up. The bar was then lowered and each machine put in a lifter, lettered *LB*, *CB* and *RB*. The blasting charge for a round generally consisted of about 100 sticks of 100% gelatin, 150 sticks of 60% and 250 sticks of 50%.—*Eng. and Min. Journal*.

#### CHEAP GAS

The Widnes Corporation, of England, which for years has held the proud position of purveyor of "the cheapest gas in the world," has further strengthened that position by making another reduction in price. The last reduction cuts the price to consumers within the borough 2 cents per 1,000 cu. ft., making its price to consumers below 3,000,000 cu. ft. per annum, 24 cents net per 1,000, to consumers over 3,000,000, 20 cents net, and to all users of gas for motive-power purposes, 16 cents net. This cut was made possible by the improved carbonization resulting from a new installation of horizontal retorts which will make Widnes gas from 20 per cent. to 27 per cent. cheaper in price than that of its nearest competitor, the Sheffield Gas Co. Only recently was celebrated the inauguration of a new carbonizing plant which cost the city about \$200,000, but which will decrease the cost of production, while largely increasing its output.—*Gas Age*.

## AIR COMPRESSOR EXPERIENCE CAULKING LEAD WOOL JOINTS

BY DANIEL J. HIGGINS.\*

My first knowledge of the Air Compressor was some twenty years ago, and at that time the term Air Compressor loomed up mighty big to me. I was then a pattern maker and an air compressor was to be built for the famous firm of Engineers, Westinghouse, Church, Kerr and Company. It was considered quite a thing to make the set of water jacket cores which surround the air cylinder for cooling. This machine was manufactured, finished up, and, if I recall correctly, a test was made and the first casting of the compressor end was found to be porous, air being forced through the iron.

From that time on, air compressors have crossed my path in many ways. I have had four years experience in the United States Navy, and the wonderful work that the air compressor performed in marine work was most notable. The compressor plant is located in any available place, and is so arranged that, with the hose connection, it can transmit power to drive tools in isolated places. In marine work, especially in the work of drilling, riveting and caulking the steel sides of our battleships, it is a very wonderful invention. To-day a very light tool in the hands of a skilled man does a phenomenal amount of work as compared with the amount done with hand tools.

You have but to observe, those of us who have opportunity of being in large cities, the start of a sky-scraper building. The structural steel comes in the "knock-down" from points in Pennsylvania, is landed in Boston, New York, Chicago or San Francisco, and, with just the aid of the crane or derrick, the pieces are put in place. We find the riveter with his air tools following the setting of the frame of the building, and, before long, we have any number of stories securely knit together.

Where would the structural iron workers be without the Air Compressor? It is true they are a very capable class of men while working in gangs, but this cuts the gangs down several men. A gang usually consists of the

butter up, two riveters and the heater boy. With the aid of the Air Compressor, all that is needed now is the butter up and one riveter. This decrease of expense seems small, but figured on a large job it amounts to quite a sum in dollars and cents, besides the saving in time.

In machine tool work, we find many instances where the air compressor is brought into play. Foundry work to-day is greatly aided by an air compressor. Having an Air Compressor in a foundry plant, we find all our castings sand blasted and also moulding machines run with air. After the casting is made and cleaned, we see an air tool used on the snagging of the casting.

### CAULKING LEAD WOOL JOINTS.

Last year, we had occasion to lay about ten thousand feet of 10-inch pipe. After making the necessary plans and estimates, I happened to get in touch with a manufacturer of air compressors, and there were some things in the small machine he offered which appealed to me for caulking lead joints. The main features were that it was portable, not too heavy and with enough power to run the caulking hammer comfortably. The whole outfit cost less than \$450.00, and showed in the end that this job almost paid for the machine. The first cuts which were shown me did not appeal to me particularly, as they showed a wooden bed. I took up the matter with the manufacturer and asked to have this machine made on a channel-iron bed. This was done, and since that time, all machines are made with channel-iron beds. They made certain claims for the wooden bed, but after having our channel-iron bed under severe usage, I was convinced it was the proper thing.

The machine which we purchased was directly connected with a single cylinder, four cycle gasoline engine to the air compressor, pumping directly into a vertical tank placed on the same bed. On top of the tank was arranged a safety valve and also an air valve. Beyond the air valve was a slip joint and lock coupling for air hose. We had fifty feet of hose and after placing the machine on the street side of the ditch, opposite the side where the gravel was to be thrown out, we found that by placing the machine at any point 50 feet from where we started, we could caulk 100 feet without moving the machine: That is, we ran 50 feet back of the machine and

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\*Superintendent Water Department, Waltham, Mass. Paper read at Boston meeting New England Water Works Association, Sept., 1914.



LEAD WOOL CAULKING ON BIG WATER MAIN.

then 50 feet ahead. This put in practically eight joints.

In one 5000 foot section, we ran across about 1000 feet of ledge and rather than call in a contractor, or drilling the ledge out by hand, I decided to buy an air drill. This cost about \$68.00 with a set of drills, and we removed 1000 feet of ledge. We found this was a very good investment as we have used the machine many times since then for removing ledge and have also found it profitable to transport it to various points in the city to remove large boulders when we ran across them in the trenches.

Now, as to caulking, we used the best Omaha lead and, instead of a straight bell, we used a beveled one, because it was necessary to have more lead protruding slightly beyond the bell end when caulking with the machine. This would seem to indicate that the lead was more firmly forced into the joint, and we have nev-

er split a bell. The length of time necessary to caulk a joint was nominally about three minutes to the joint, as compared with fifteen minutes under former conditions. Our first caulking tools were made a trifle long, and after experimenting with them we decided that a short tool was more practicable.

At first our caulking gang was a bit timid in using the machine. They were under the impression it was going to cheat them out of a job, but after a few demonstrations they realized the machine was a powerful aid to them, and later realized the wonderful power behind the blow of the air hammer. We found that under-side caulking was made much easier, on account of the hard position and reaching that caulkers had to assume in order to do satisfactory work under old conditions. The machine works just as well underneath as on the sides and top, where access is much easier.

In my first crew was a fairly intelligent man

to run the machine and also to lend a hand in setting the pipe. I found at first that this fairly intelligent man was addicted to the very serious habit of using a screw driver and monkey wrench on the machine, and would not do as he was told. This lasted several days and we finally had to let him go. A high school boy, formerly water-boy for the gang, was taken and put running the machine with the same instructions as given the former man. He proved a wonderful success, followed instructions to the letter and we had much better results than at first.

The portable air compressor differs from all other plants of this kind. The engine and the compressor are combined in one machine. The air piston is connected on the same crank shaft as the engine piston, making what is known as a double throw method, which gives absolutely the same speed and power to the compressor as the engine. Another improvement is the piston discharge valve instead of the old style stem-valve, which makes it possible to reduce the valve space behind the air piston to a minimum. This valve also increases the efficiency about fifteen per cent. and is practically indestructible. The compressor is also equipped with an unloader which automatically relieves the compressor at any desired pressure up to 125 pounds. The engine is equipped with a magneto which makes the use of batteries unnecessary. The gasoline supply is retained in the base of the engine.

The requirements of a properly caulked joint involve a rather tedious and slow operation when performed by hand. In addition it is expensive and lacks uniformity and reliability. This is most noticeable on the under side of a joint, due to its inaccessibility. The pneumatic hammer gives an absolutely uniform joint on top and bottom.

The specifications of the Compressor are as follows:

Engine—5 H. P.: hopper water cooled.  
Compressor—4½x6 in. air cooled.  
Capacity—23 cu. ft. free air per minute.  
Size of air tank—20x60 in. or 30x60 in.  
Total weight—With 20 in. tank 1650 lbs.,  
with 30 in. tank, 1800 lbs.  
Total length—6 ft.  
Total width—34 in.

Pneumatic tool capacity—With 20x60 in. tank, 1 Pneumatic caulking tool or 1 Pneu-

matic rock drill; with 30x60 in. tank, 2 Pneumatic caulking tools or 1 rock drill.

The cost of the outfit was \$436.60, complete, with a caulking hammer for caulking pipe, cutting or chipping bricks or concrete, a set of 6 steels, and air hose in 50 ft. lengths. We bought an Imperiar Air Hammer for rock drill work.

In conclusion, I would state that we are firmly of the opinion that the air compressor for caulking lead joints and for rock drilling has passed the experimental stage in water works construction and I would heartily recommend it to any superintendent or engineer for this sort of work.

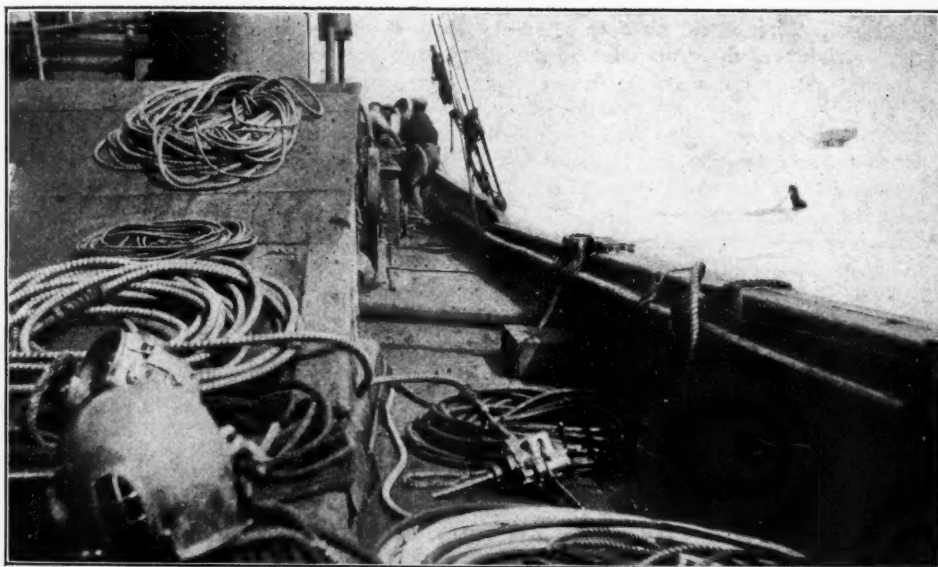
#### WORK ON THE ARROWROCK DAM

Foundation work for the highest dam in the world is an important part of the structure. The bedrock foundation of the dam lies 80 or 90 feet below the present bed of the river, although it was the original bed of the channel. It is a hard granite, somewhat seamy, but without open continuous seams. Being firm, rough and irregular, this rock is considered ideal for foundation conditions. All the excavation in the river bed, some 250,000 cubic yards, was completed by April first of this year, and the dam itself had been carried to a height of 140 feet, out of its total of 350 feet. More than 200,000 cubic yards of concrete had been placed in the dam, equal to about 36 per cent. of the estimated total. Concrete for the dam proper is mixed about 1 part sand-cement, 2½ parts sand, 5½ parts gravel and 3 parts cobbles; but for a thickness of 5 to 10 feet against each face a richer mix is used. There are three mixer units at the plant, two being in use for two 8-hour shifts, six days in the week, and the third being reserved as an emergency unit. Cableways lead from the mixing plant to the site of the dam, and the cableway bucket discharges automatically into a hopper, suspended from the cableway and held stationary by snub lines while in use. At the bottom of the hopper is a chute 40 feet long, the free end of which may be swung in any desired direction. A gravel pit was established along the line of the Arrowrock Railroad and a steam-shovel outfit with screening and crushing plant was installed. This is about 14 miles from the dam and the sand and gravel are hauled to the mixing plant in standard-gage bottom-dump cars.

Tracks are extended over the tops of storage bins at the mixing plant and the cars dump the material directly into the bins. The sand-cement plant is across the river from the mixers, the transportation being through lines of 4-inch pipe by means of compressed air. The gates of the measuring boxes are also operated by compressed air. The average unit costs so far have been for excavating the foundation \$1.07 per cubic yard, for spillway excavation, \$0.65, and concrete in dam, \$3.73 per cubic yard.—*Steam Shovel and Dredge.*

fouled and life lines cannot have a direct pull, and especially where, as in this case, the working pressure approaches the limit of endurance. One diver, by the way, has already lost his life on this job. It was determined, therefore to cut a number of holes in the inclined side of the ship to give the men short and direct entrances to certain locations where they might expect to make the most important finds.

The general scheme was to cut a number of rectangular openings, say 4 feet or more in



ON DECK OF WRECKING BARGE.

### SALVAGE OPERATIONS ON THE EMPRESS IRELAND

BY FRANK RICHARDS.

It having been definitely settled that it is practically impossible to raise the great steamer *Empress of Ireland* so unfortunately sunk in the Lower St. Lawrence, the next thing is to save whatever is possible from the wreck, all the bodies of the drowned that can be reached, the mails and the bullion, of which there was a large amount. This work of salvage is being conducted by the well known firm of King & Wotherspoon, 24 State street, N. Y. City.

When working in the interior of a sunken vessel the divers very properly object to following intricate passages where air pipes may be

dimensions, right through the steel plates, giving the divers free passage through them, and four or more of these holes have been cut at the present writing. For each side of the rectangle a row of holes are drilled as close to each other as possible defining the opening all around and then the piece enclosed is torn out. This job is not as easy as the telling of it, the most difficult part of all, perhaps, being the drilling of the first one or two holes on account of the difficulty of applying the necessary pressure behind the drill to make it cut. After two corner holes have been drilled, hook bolts can be inserted and these are made to support a steel beam placed at such a distance from the sheet as to form a proper backer for the drill, and then the work is comparatively easy for

all that row. The thin portions between the holes are not cut away by chisels or otherwise, but the sheet is torn away bodily by brute force. The surface being inclined at a considerable angle, hooks can be inserted in a number of holes at once along the bottom and then a powerful pull from a hoisting engine on the wreck will do the rest. In this it is not necessary to pull the sheet entirely off, but to swing it up and let it remain there like an open door.

The drill employed for this work is known as Little David No. 2, reversible. One of these drills is seen lying on the deck in the half-tone with the wire wound air hose attached. At the depth where the drills were employed the water pressure was about 40 lbs., so that this had to be provided for by additional air pressure to correspond. The air is supplied by two Rand compressors, RC, of a type now somewhat obsolete, but which have done excellent service in other places. These are seen in the background and also a portion of the steam boiler temporarily installed to drive them. The air for the divers is supplied by the hand operated pumps, which the divers prefer. Six divers are employed with a large gang of men for the various service required. At this writing all the silver bullion and the mail sacks have been recovered by the divers and work has been discontinued for the season.—*From Engineering Record, with additions by the writer.*

#### DEPOSITION OF METALS BY SPRAYING\*

BY R. K. MORCOM.

The spraying of metals from the molten state in order to produce a powder is an old idea, and the spraying of a liquid to produce a covering of paint, varnish, or enamel, is also well known. The subject of this paper is akin to them both, but has for its object the production of uniform metal deposits by means of a spraying process.

The earliest attempts in this line were carried out by melting the metal in a pot, forcing it through a fine nozzle under high pressure, and then with steam or a gas spraying it on to a surface. The spraying medium was kept hot by various devices, and an attempt was made to keep the metal molten right up to the moment of application. The fact, however,

was observed that under conditions of temperature and expansion of the gases such that the metal could not have been molten throughout the process, adherent coatings were sometimes formed. These experiments, and careful observations of the spreading and adhesion of bullets fired at an iron plate, suggested the next stage of development. Metallic powders were driven at high velocity against the body to be coated by means of gaseous jets expanded from considerable pressure. The results achieved were a great improvement on the older method.

To produce the metallic powders the metal had, of course, to be subjected to one of the known pulverising processes, such as distillation, grinding, or spraying. The suggestion that the pulverisation and deposition could be combined in one apparatus was then made by the inventor, Schoop. The steady improvement of this apparatus in the laboratories of Schoop and his associates has resulted in the machine sketched in Fig. 1. The essential parts of the machine, or "pistol," as it is called, are a combined melting and spraying jet and a feed mechanism. The metal, in the form of rod or wire, is fed to the melting flame. The flame can be formed by coal gas, water gas, acetylene, hydrogen, etc., burning in air or oxygen according to the metal used. The gases are supplied at such pressures as to prevent blowing out and to ensure a highly deoxidising flame. The spraying jet can be of carbon dioxide, nitrogen, air, steam, etc.; it is fed at such a pressure as to produce a sufficiently high velocity for successful coating. The various pressures must be carefully kept constant by accurate gauges and reducing valves.

The feeding of the wire is accomplished by a small pneumatic motor, driven by the spraying medium, either in series or parallel with the main jet. The dimensions of the wire nozzle, and feed mechanism vary with the different metals, and the nozzles and feed mechanism are so designed as to be readily interchangeable.

For small work hand operation is sufficient; but, probably, when large work is undertaken, it will prove convenient to have mechanical traverse and control.

To obtain the best adhesion, the surface on to which the metal is sprayed must be thoroughly clean and of an open nature to give a key for the deposit. Sand-blasting with sharp

\*Annual Meeting Institute of Metals.

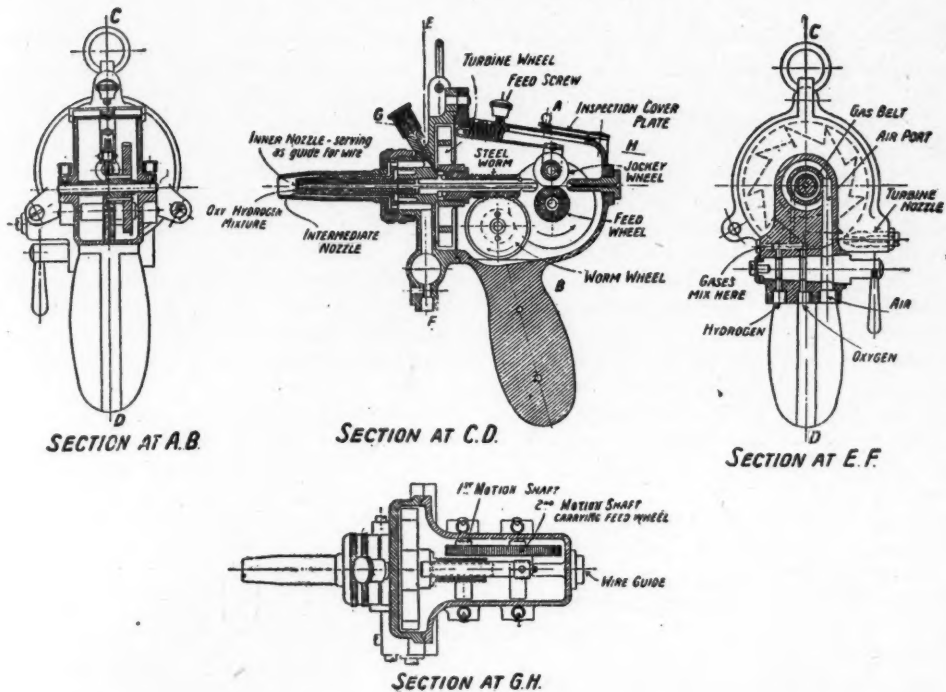


FIG. I.

sand has been found best. Shot gives too polished a surface. Such surfaces as fabrics, wood, unglazed earthenware, and asbestos require only freedom from grease, as their surfaces give a natural key.

The mention of wood and fabrics as suitable substances to coat by means of an apparatus in which an intense flame is used may cause some surprise, which will be increased by the statement that celluloid, and even explosives, can be safely metal sprayed. To make this less remarkable it will be well to enter here upon a brief account of the theory so far developed to explain the operation, referring to Fig. 2 in the first instance.

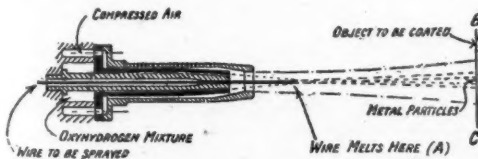


FIG. 2.

The melting jet is focused at A on the tip of the wire. The spraying jet, cold from expansion, strongly draws forward the products of combustion in the centre of its cone, and by its

draft drags off minute particles of metal, either in the plastic or molten state. The central cone, therefore, consists of metal particles, some cooled to solidity, some molten, and some perhaps gaseous, surrounded by a protective reducing atmosphere. This cone is hurled forward with great velocity on to the object to be coated, BC, by the outer jet.

With a given design of jet there is only a certain volume left by the air-jet which can be filled with flame, and this flame has a limiting temperature which cannot be exceeded. The wire, passing through this cone of flame, receives heat partly by radiation, but chiefly by conduction, and becomes melted; but there is a definite limit to the amount of heat which can be picked up by the wire passing through the flame, and a definite limit to the rate at which it can be melted. This cannot be increased by forcing more gas into the flame, as the extra gas is merely blown away by the air-jet. It is possible to increase the rate of melting by shaping the nozzles so as to leave room for a larger cone of flame, and experiments are in progress on this point. There is, therefore, a definite and most economical quantity of gas which should be used in the pistol, this quantity being about 1.5 cu. ft. of

hydrogen per minute, and 0.5 cu. ft. of oxygen; or about 0.8 cu. ft. of coal gas to 0.65 cu. ft. of oxygen for the present standard designs.

In refractory metals these quantities may be increased slightly, as a slightly higher temperature can be obtained if the burning gases are under a pressure greater than atmospheric; and this occurs if the gas quantities are increased, the inner surface of the air-jet acting to some extent as an enclosing wall to the flame. On the other hand, for the more easily fusible and oxidisable metals, such as tin, lead and zinc, it is advisable to keep the gas quantities rather below the figure given, so as to avoid any possibility of overheating and burning any portion of the wire.

The outer jet performs a threefold function, it keeps the nozzles and wire cool, it cools the object, and it produces the requisite velocity. The velocity of the air leaving the jet will be independent of the volume discharged, and depends only upon the pressure at the jet, so long as there is no disturbance due to the entraining of air from the surrounding atmosphere. This, of course, will actually occur in practice, and the layer of air must have a certain thickness in order to prevent its being broken up, and having its velocity destroyed by mixing with the surrounding atmosphere.

In addition to this, the air-jet has to atomise the molten metal, and accelerate the particles up to its own velocity, so that to perform this a certain mass of air is required.

As at present constructed the standard pistol, uses about 0.55 to 0.6 cu. ft. per minute for every 1 lb. per sq. in. air pressure, so that with an air supply at 80 lbs. per sq. in., which is a very suitable figure for ordinary spraying, the air consumption will be from 45 to 50 cu. ft. per minute. The mass of metal sprayed by this air will be from about 8 grammes (0.28 oz.) in the case of iron to about 200 grammes (7.05 oz.) in the case of lead.

The effectiveness of the cooling is readily shown by the fact that the hand can be held in the jet, so as to receive a coating of metal, without inconvenience.

The action of deposition is probably a complex one. The minute particles of solid metal are driven with such force against the object that in some cases they fuse, but, owing to their small relative size, are promptly chilled by the object to which they adhere. If any of the particles are molten or gaseous they will adhere. In addition, the suddenly chilled

particles are possibly, or even probably, in the state of unstable equilibrium found in "Prince Rupert's Drops," and act like so many minute bombs, bursting on impact into almost molecular dimensions, and penetrating the smallest cracks and fissures of the object.

The process requires some care in manipulation as, by varying the conditions, it is possible to spray porous or non-porous coatings, and, with some metals, anything from a pure metal to a pure oxide. With care, however, non-porous, oxide-free, adherent coatings can be produced, of almost any metal on almost any solid.

In addition to metals, it is possible to spray fusible non-metals, or, by stranded wires, alloys of metals or mixture of metals with non-metals.

The process is so new that uses are still partly to be developed. But it is easy to see that it may have far-reaching value for protective coatings against weather or fire, for ornament, for electrical resistance and conductors, for the production of special alloys, for joint making, and for many other purposes.

Quite in a different category comes that of very fine casting. The surface of a pattern polished or slightly greasy, is most minutely copied, and it is possible to produce process blocks very rapidly. It may be useful to line moulds before pouring in a metal. The application of the process to the production of very fine or coarse metallic powders is being investigated.

The costs of the process are not prohibitive, and, even where higher than alternative processes, the great range and adaptability of this apparatus, and its independence of muffles, pots, etc., may make it preferable.

A table of gas-pressure and feed rates is appended to give some idea of costs. Experience and extended use on a commercial scale should soon reduce the cost of operation.

The bulk of the work has hitherto been

Metal.	Diam. of Wire used Millimetres.	Rate of Feed, Grammes per Minute.	Gas used per Minute, Cubic Feet			
			Hydrogen.	Oxygen.	Coal Gas.	Oxygen.
Aluminium . . .	1.0	25	1.5	0.5	0.7	0.6
Brass . . . . .	0.8	17	1.5	0.5	0.8	0.65
Brass . . . . .	0.8	17	1.5	0.5	0.8	0.65
Copper . . . . .	0.8	14	1.5	0.5	...	...
Cupronickel . . .	0.8	12	1.5	0.5	...	...
Gold . . . . .	0.8	45	1.5	0.5	...	...
Iron . . . . .	0.8	8	2.0	0.7	...	...
Lead . . . . .	3.0	300	1.0	0.35	...	...
Nickel . . . . .	0.8	9	2.0	0.7	...	...
Silver . . . . .	0.8	18	1.5	0.5	...	...
Tin . . . . .	2.0	200	0.8	0.3	0.25	0.25
Zinc . . . . .	1.0	45	1.5	0.5	0.25	0.5

carried on in laboratories, but the apparatus is gradually becoming used in the more progressive factories, where extended facilities, and the knowledge of specialised requirements, will ensure a rapid improvement in technique and results.

The research on the lower melting-point metals has been greater than on the others, and undoubtedly the economy with them both can be greatly improved. Preheating of gases and air, supplementary flames acting in front of the main jet, and electrical methods of heating, are all still the subject of experiment.

Fig. 1, taken from the main plant, shows the site of the wells to be pumped, and Fig. 2 is a view of the main plant from well No. 1 in the previous view. The wells were to be pumped by the air lift, and the brine was to be conveyed from one side of the lake to the other, which compelled the laying of both a brine pipe and an air pipe to cross the lake, the former being 6 in. diameter and the latter 4 in.

#### LAYING THE PIPES.

These pipes were put in under the supervision of men furnished by the Union Tank Line Company, and the laying of them illus-

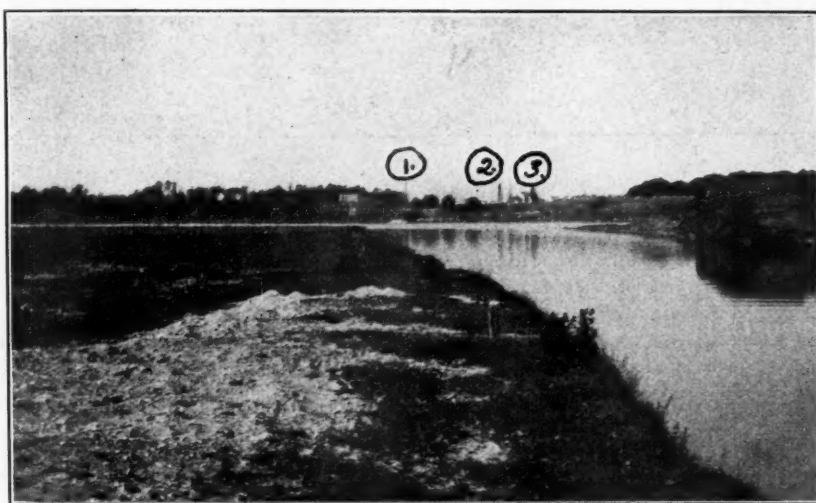


FIG. 1.

#### AN AIR LIFT ENGINEERING FEAT

BY FRANK RICHARDS.

I trust that many readers will be interested, as I have been, in learning some particulars concerning a recently successfully completed plant which may be characterized as unique in more than one particular. The Morton Salt Company operates a permanent installation at Ludington, Mich., the original wells and the evaporating, packing and shipping establishment being on the shore of Lake Marquette, which here is about three quarters of a mile across and 35 feet deep. Some valuable wells which it was desired to bring into operation are situated on the other side of the lake, and it was desired to operate them without constant attendance or the expense of an isolated power plant.

trates the reliable practice which unlimited experience has developed. It might be thoughtlessly called rough engineering, but complete success, quickly, surely, cheaply secured is never to be sneered at, especially by those who could not have done as well. The two complete lines were put down in less than 20 actual working hours. The line was first laid across the lake on the ice, and then, the ice being cut away, the pipes were lowered to the bottom. The joints of the pipes were the ordinary screw thread couplings, and, as there was no preparation of a bed for the pipes to lie in, they were left to accommodate themselves to their bearings as best they could.

Fig. 3 shows the pipes after they were laid just where they emerged from the lake toward the wells, No. 1 being the 6 in. brine pipe and No. 2 the 4 in. air pipe. Attention is es-

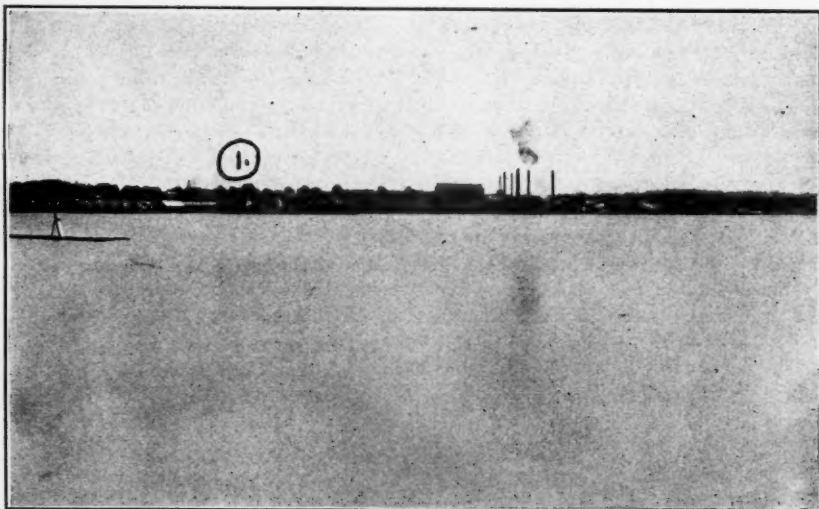


FIG. 2.

pecially called to the long, stiff clamp seen on the pipe in this view. This clamp covered the pipe and coupling and effectually protected the threads of the latter from the bending strains which occurred. Air was transmitted through the pipe at a pressure above 225 lb., and surely if this pipe could be made air-tight—as it was

—there should be no excuse for air leaks anywhere.

#### THE COMPRESSOR.

The compressor installed at the power house for serving these wells is shown in Fig 4. This is an excellent photo of a machine as taken when running at full speed. The arms



FIG. 3.

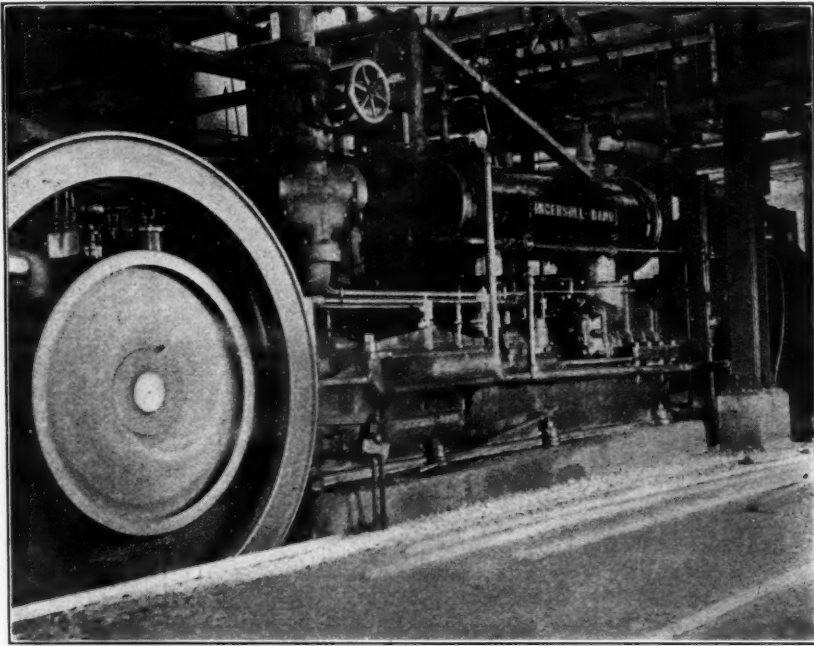


FIG. 4.

of the flywheel have entirely disappeared, as has also the crank pin, and only a slight blur outlines the area traversed by the connecting rod. The crank disk shows an overhanging lip which is valuable for catching oil that otherwise would be thrown off by the centri-

fugal action. The gutter around the disk can of course be wiped out whenever the compressor is stopped. There are no immediately novel features about the compressor; it is of the straight line type technically designated as Ingersoll-Rand, AA2. The steam cylinder

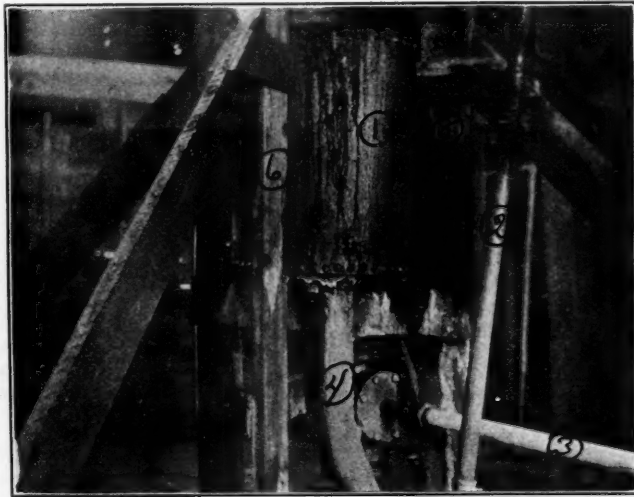


FIG. 5.

is between the flywheels and the piston inlet, low pressure air cylinder is at the further end, with the high pressure air cylinder inside and connected by a large overhead intercooler. The steam cylinder is 24 in. diameter, and the air cylinders are 19½ in. and 9¼ in., respectively, with a common stroke of 24 in., and a capacity, at 140 R. P. M., of 1100 cu ft. of free air per min. delivered at a pressure as high as 300 lb., which, by the way, is higher than the normal working pressure for a machine of this type.

#### THE AIR LIFT.

The air lift operation in this case is somewhat complicated. The air is delivered to the wells at a pressure of 225 lbs. The pipes are carried down to a depth of 700 ft. while the lift is 335 ft. to the booster, which gives a submergence of about 53 per cent., and a surplus of pressure in the booster after the delivery of the brine. This surplus pressure, about 22 lb., is employed to drive the brine through the 6 in. pipe under the lake 4400 ft. and elevate it 48 ft. to the settling basin, from which it is distributed to the evaporators and grainers. Besides doing this work there is a considerable volume of air remaining at the booster which is carried down to the lake where it serves as an air lift to elevate fresh water high enough to flow back to well No. 2. It flows down this well by gravity into a common cavity where it dissolves the salt, forming the brine which is pumped through wells 1 and 3 to the surface.

Referring to Fig. 5, 1 is the booster itself, 2 is the surplus-air pipe for the fresh water service, 3 is the air-and-water delivery pipe from the wells, 4 is the 6 in. pipe for the long run of the brine to the other side of the lake, while 5 and 6 call attention to the mode of supporting the booster to make all the pipes accessible.

Economy of operation was considered in this installation, but the main point was reliability. The air lift in detail is not as simple as above outlined. Harris pumps of special design being employed. The air actually passes down the wells outside of and around the brine line, or, in other words, the discharge pipe is inside the air pipe.

There would have been no economy in using a condenser for the steam in this case, as all the exhaust is used under the evaporating pans.

For the photos and for the information here presented I am indebted to Mr. James C. Gillies of the Chicago office of the Ingersoll-Rand Company of Illinois.—*Practical Engineer.*

#### THE FLY AND THE BOTTLE

BY A. L. HODGES.

The old story about the fish being put into a tub of water and not making it weigh any more has of course long been disproved; but a new proposition in the form of a fly and a tube has arisen to worry those so minded. Suppose you have a tube that weighs so much, and then place a fly into the tube and close it so that it is air tight. Now of course, if the fly alights on the side of the tube, his weight is added to that of the tube; but suppose that he is just flying around in the tube without touching the sides? It is inevitable that his weight must come just as it does when he is on the side; for we are weighing an air-tight tube and its contents, and it is immaterial about the condition or position of those contents, provided the tube is full of something. The fly, to sustain himself, has to beat downward with his wings, and thus exert pressure on the inclosed air equal to his weight. In case there was a vacuum in the tube and the fly was momentarily dropping inside without touching the sides, he would of course weigh nothing on the scales in this position.

But the hardest question is yet to come. Suppose that the tube is open to the air and that the fly is flying around inside without touching the sides, then will his weight be added or not? The answer to this is the same as when the tube is closed, but will have to be extended somewhat. Whether the extension will apply to the closed tube, however, is a question, and depends on whether we may consider it a system of isolated forces. When the fly is not moving up or down he is exerting exactly his own weight downward, whether the tube be opened or closed; therefore his weight would have to be added if he was not touching the tube but was simply keeping at one spot in the air in the tube. If he flies upward, however, he is exerting more than his weight downward, and will add more than his own weight. If he flies or falls downward, he does not add quite his weight to the tube's. If he flies downward faster than sixteen feet the first second, he will actually make the tube lighter on the scales than it is without the fly.

# COMPRESSED AIR MAGAZINE

EVERYTHING PNEUMATIC

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### CHEAPER WORKING AND MORE WORK

Whatever we do if we are interested in our work; if we aim to accomplish the most and to produce the best, with economical use of means and methods, which is the universal attitude of modern industry, it invariably results that what we find to do is constantly done quicker, cheaper and better. One rarely can tell from the rate and cost of our working to-day what these conditions may be far in the future, but improvement and increasing facility we may be sure of.

The tools and apparatus employed in our work are constantly being superseded by better, even before they can be worn out, and this is nowhere more true than in the lines of industry which specially interest our readers. Few who are not in close touch with the actual thing can realize what improvements have developed within a decade in air compressors and rock drills and in the way they are used. Compressed air has not changed its characteristics, and it still is the great reliance where rock excavation is to be rushed, but there is less noise and display.

Only a little while ago right in the heart of New York City the Pennsylvania and the New York Central railroads were building their great stations, cutting deep and wide into the solid rock for yard room as well as for the buildings. There were great power houses for the compressors, and over the rocks were distributed the heavy tripod drills, laboriously shifted from hole to hole. At the present moment, and only a hundred yards from where we write, there is another great and deep hole being cut in the rock as required for the new subway construction. Of course compressed air had to be employed for the work, and there is a compressor somewhere, but it is not easily found, and in place of the heavy drill and tripod there is a Jackhammer, a one-man drill which the man can carry under his arm or on his shoulder, and with which as soon as he has finished one hole he is immediately ready to begin another.

Just a look and the striking change is impressed upon us, and we have no wish to "improve the occasion" by any funeral sermon. Rock drilling or rock excavation is vastly cheaper than it was. The cost of mechanical equipment is cut in half and the cost of operating is proportionately reduced, so far as the drilling is concerned, which means, for the

first part of it, that those who build machinery of this class have perhaps not more than one-half the amount of work to supply the normal demand.

This, however, is not the whole of it. The cheapening and the quickening of our facilities for doing work lead invariably to the planning and to the doing of more work. Many schemes which would have been too costly by the old way come to be possible and are set going. New undertakings are planned ahead and each thing completed leads to several new things to be done. The way to get work is to work cheaply and efficiently.

This is perhaps nowhere more true than as regards the local work of building and extending the Metropolis, in which compressed air and the rock drill are such constant and appreciated workers. There is now within its limits one of the world's great engineering works approaching completion and others are just beginning, neither of which would it have been possible to think of but for pneumatic aid. These latter subways and tunnels under way are not the end of anything, but soon will be intermediate in a series which is not to stop. Not only must there be more and more subways for passenger traffic, but is it not time also to be providing for the conveyance of merchandise and freight?

And so the work will be coming along, for the whole nation and for all the world.

### PREHISTORIC MINERS

BY GARRET P. SERVISS.

Prehistoric man is continually becoming plainer to our eyes as science clears away the mists of early time, and the more we see of him the more we find to admire in his achievements. Recently extensive explorations have been undertaken of the mines that were dug by men of the Neolithic age at Spiennes, not far from the present city of Mons, in Belgium.

Mines! What had prehistoric man to do with mining? What was he digging for? Digging for that which for him was as valuable and as indispensable as iron is for us—flint. He knew nothing of metals, but he had to have spear and arrow heads for himself, kitchen knives for his wife, and a variety of working tools to keep the whole family from mischief, and he made these things out of flint.

The first makers of flint tools and weapons

were very rude craftsmen, and they took their raw material wherever they could find it—a chunk of flint picked up here or there served their purpose. But early man was not long in demonstrating that he was no slave of mere instinct, like bees and ants and other animals which know no progress, and do the same things in the same way for a million years. His intelligence showed him that he could improve upon himself and upon nature by setting his mind, his invention at work.

As his tools became finer in quality and finish he needed better materials to work with, and he set out to find them. Some great flood, perhaps, cutting deep into the chalky soil, showed him that far beneath the surface there were layers of flint nodules much superior in quality to those that he had hitherto used. He felt that he must have that better kind of flint, cost what it would, and so he became a miner.

The explorations to which I have referred show that certainly hundreds, and probably thousands, of deep mine-wells were dug by Neolithic men in the chalky plateau at Spiennes in order to reach deposits of specially fine flint existing at a depth of fifty feet beneath the surface of the ground. There was plenty of fairly good flint above, but these workmen were becoming very particular in their judgment of the material that they used. They wanted tools and weapons that would take and keep an edge and that would not crumble in an emergency. In those days, just as truly as to-day, the best weapon won the battle, the best knife struck deepest.

Photographs from the excavations show how ingeniously the men of that time dug their mines. They knew as well as the coal miners of Pennsylvania how to support the roofs of their galleries.

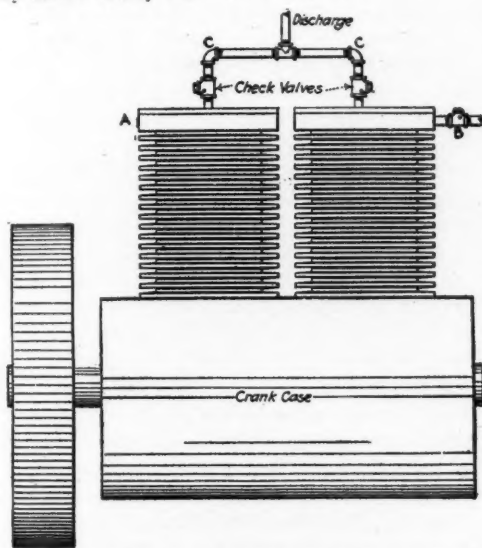
Around the openings of the mines, at the surface, indications are found of the existence of the workshops of the artificers in flint. There, too, as well as in the abandoned mines, are found many flint picks, whose wooden handles decayed and turned to impalpable dust many centuries before Rome was founded. It was with such implements that this vast system of mines and galleries was excavated by those early, simple men, whom we are accustomed to regard as far below even the savages of to-day.

But they possessed the virtue of perseverance. They knew what hard unceasing work

meant. Measured by the effort required to get it, their flint was as precious as our gold.

"If you would appreciate the industry of these Neolithic men," says one of the investigators of their work, "take one of those flint picks, just as it dropped from their hands, fasten a handle to it, and then go to work and dig a well fifty feet deep, and galleries hundreds of feet long, and see how long it will take you."

Those were, indeed, the days of hard work; the days when man was finding his true worth, and when the value of labor was measured not by hours but by results.—*The Sun*.



A GAS ENGINE TRANSFORMED INTO AN AIR COMPRESSOR

The sketch here reproduced from *Power* shows how a correspondent rigged up an old gas engine to serve as an air compressor. A perhaps sufficient excuse or explanation was that the air requirement was something of an experiment and that only about 40 lb. pressure was wanted.

The engine had a closed crank case and a belt wheel on one end of the shaft. The spark plugs being set in as at A, it was only necessary to ream out and tap these nobs to  $\frac{3}{4}$  in. and screw into each a close nipple and a common check valve as at B, for the intake. The head plates were drilled and tapped for  $\frac{1}{2}$  in. nipples with check valves for the discharges. The two checks were then piped together—using a union forgotten in making the sketch—and the compressor was ready

to run. The cost of the change was about \$6.00.

Of course it worked, but the valves were not suitable for the purpose and the clearances must have been so large that volumetric efficiency was out of sight.

#### LAYING A 12-INCH PIPE LINE 120 MILES LONG

Readers of *Compressed Air Magazine* are naturally interested in the laying of pipe lines, although the length of the line here spoken of is greater than compressed air practice usually calls for. It, however, is connected with compressor service and carries high pressures, both particulars combining to make legitimate reading for us.

The 12-in. line here spoken of is for the conveying of natural gas at high pressure from Inez, Kentucky, to Louisville. The work of laying the pipe was described in an interesting paper by Lewis S. Streng before the Engineers' and Architects' Club.

The work was begun on Aug. 8, 1913, and completed and tested on March 12, 1914. The unusual difficulties of the undertaking were due largely to the character of the country.

The work on the Louisville end was simple compared to that in the mountains. Delivery of material was a problem. In some places, the nearest railway was 40 miles distant, and the wagon roads hardly deserved the name. A team would start from Paintsville with two lengths of pipe, the load amounting to less than a ton, and return light, taking three days for the round trip. About 150 teams had made several trips, the roads were in miserable condition, requiring a repair gang to keep them passable. On the Louisville section, much foreign labor was employed, but not back in the hills. The mountaineers drove the foreigners out of the country. The mountaineers were splendid workmen. They would walk four or five miles before daybreak, do a day's work and go back home with a lantern.

#### DETAILS OF PIPING.

The steel pipe used was 12-in. inside diameter,  $\frac{3}{8}$ -in. thick, weighed 45 lb. per ft., and averaged 20 ft. to the length or "joint" as it is called. Each joint was tested at the mill at 1,000 lb. per sq. in. pressure and carefully inspected for defects. The couplings used were steel forgings of the familiar Dresser type, consisting of a central ring, two rubber-com-

pound gaskets and two followers drawn up by steel bolts. Screw pipes were used in all river and creek crossings, with leak collars with rubber gaskets placed over each of the screw couplings, and over all this was bolted a heavy split-iron casting, or river clamp. Under all rivers, two lines were laid with valves and Y's at either end. At railroad crossings, the pipe was placed in a 20-in. cast-iron casing, fitted with valves, on either side of the right-of-way. Eventually, a second line will be laid, with provisions for cutting out any section desired. In case of trouble, the check valve will prevent the escape of gas from the Louisville end.

#### TESTING.

The line was tested as laid before any of the couplings were backfilled. For testing purposes, two temporary compressor stations were erected, one on the Kentucky river, about 7 miles above Frankfort, and the other on Mud Lick in Johnson county. The line was pumped up to 350 lbs. per sq. in. pressure, and then carefully inspected for leaks. The excellent results obtained by this method were shown by a 48-hour acceptance test of the whole line last February. At 350 lbs. per sq. in. pressure, the leakage in 24 hours was less than  $\frac{1}{4}$  per cent.

#### CONSTRUCTION PROCEDURE.

The construction force was organized in two divisions, one for the mountains and one for the Blue Grass, each in charge of a general superintendent. The headquarters of the mountain division was at Paintsville, with a territory to be covered of about 65 miles. The other division was about 115 miles long, with headquarters at Lexington. Each division had two large gangs, with full camp equipment. These gangs started at the compressor stations and worked toward the ends of the divisions. In addition, each division had a special gang which installed the river, creek and railroad crossings. After more than half the work was finished, another gang was organized to hasten the completion of the work. The number of men in each gang varied from 200 to 500. During the preceding summer, a survey had been made, and most of the right-of-way obtained. Stakes were set every 200 ft. and the first job of the construction gangs was to clear the right-of-way from 16 to 20 ft. wide. The digging crew then roughed out the trench throwing the earth to one side, the other side

being left clear for pipes. Where rock was encountered, a drill gang came next and the way blasted. After them came the graders, who trimmed the trench to proper dimensions, normally 18-in. wide by 36-in. deep. Changes of grade up to perhaps 5 deg. could be made in the couplings; but in general the straight pipe was laid at an even grade, and fire bends made where necessary. A small gang went ahead inspecting the pipes, dressing off any roughness at the ends, and making the necessary bends. The pipe was then laid on skids over the trench and the couplings fitted. After a section had been finished, the lengths varying from 100 ft. to  $\frac{1}{2}$  mile, according to topography, the gang came back and lowered the pipe into the ditch. Lastly, followed the backfilling gang. On level stretches, teams with drag-scrappers were used. On the slopes, breakers were built to hold the fill and leave the couplings exposed. Following the laying of the sections in the trench and their testing out, a small gang covered the couplings and trimmed up the fill. The task of hauling material was a serious problem, as has been described, but that of stringing the pipes along the right-of-way was even more difficult. At convenient locations, the pipe could be unloaded where desired, snatch teams being added as required. Frequently, however, block and tackle were required. Five or six teams were sometimes needed to move a single joint. On some of the trenching, gasoline-driven drag-line ditching machines were used. In good going, they could dig 2,000 ft. of 18x35-in. trench in a day; but they were useless on grades, or where rock was encountered. They traveled very slowly and lost much time by necessary detours. The best day's work reported by any of the gangs was about 1 mile of ditch. Occasionally, pipe gang would report as high as 6,000 ft. of pipe laid in a single day; in the rough country, 750 ft. was an average day's work. At times, when practically the whole trench was through rock, a gang of 200 men could not make more than 200 ft. per day.

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One horsepower-hour is equivalent to 2545 B.t.u. In a pound of Pocahontas or other coal containing 15,000 B.t.u., there is enough energy, could it all be utilized, to supply almost 5.9 hp.-hr., or to raise a weight of one pound 2210 miles against the force of gravity. This energy would lift a 100-ton locomotive 58 ft.

## COST OF DRIVING THE JUALIN TUNNEL FOR JUNE, 1914

Distance driven.....	539 ft.
Average per shift.....	17.96 ft.
Average round.....	4 ft. 8 in.

Labor	Total Wages		Rate per Shift	Total Cost
	Number per Shift	Number of Shifts		
Machinemen .....	2	199	\$3.50	\$696.50
Machine helpers.....	2	180 $\frac{1}{4}$	3.25	585.80
Muckers .....	4	376 $\frac{1}{4}$	3.00	1128.25
Carmen .....	2	27 $\frac{1}{2}$	3.00	82.50
Blacksmith .....	1	31	4.05	125.25
Blacksmith helper.....	1	23	3.50	80.50
Powderman .....	1	30	3.50	105.00
Compressor man.....	1	30	4.80	144.00
Teamster .....	1	34	4.00	136.00
Dumpman .....	1	22	3.50	77.00
Total .....				\$3160.80
Foreman .....	1	30	\$6.00	\$180.00
Shift bosses .....	2	60	5.00	300.00
Total .....				\$480.00

## Supplies and Labor per Foot

	Cost per Ft.
15-in. No. 18 gage fan pipe.....	\$0.70
3-in. iron pipe.....	0.20
1-in. water pipe.....	0.045
30-lb. rail.....	0.40
No. 4 copper wire.....	0.21
Oil .....	0.03
Candles .....	0.07
Powder, 200 boxes, \$7 per box.....	2.59
Fuse, 22,000 ft., \$4.75 per 1000 ft.....	0.18
Caps, 33 boxes, \$1.25 per box.....	0.075
Labor .....	5.86
Bosses .....	0.89
Bonus .....	3.04
Waterproof goods allowance <sup>1</sup> .....	0.86
Total cost per ft.....	\$15.15
<sup>1</sup> Boots, slickers, hats for 34 men at \$15 for each.	

## FAST TUNNELING IN ALASKA

The accompanying figures cover the work done in driving the Julian tunnel in June, 1914. The work is being done by the Algonican Development Co., L. K. Kennedy, manager in charge, at Jualin, a few miles north of Juneau on the Alaskan coast. The tunnel will serve for prospecting and drainage and is to be 7000 ft. long. It is being driven in what is known as Jualin diorite. The drilling is done with two No. 18 Leyner machines. During June tramming was conducted by hand. During the month the entire 1100 ft. of track then laid was torn up and relaid with heavier rails. This work resulted in the loss of 4 rounds. At present mules are used for tramming and better footage is being made.

It will be noticed that the drills are Leyners as against the big pistons used on the Sheep Creek tunnel recently completed by the Alaska Gastineau not many miles away. The footage for June is an excellent showing. The two

tunnels should afford an unusual chance for comparison between the two types of machine. The crew consists of tried tunnel men; it was organized late in May and is in charge of A. Ricandeau who has all the work systematized to the last degree.—*Eng. and Min. Journal*.

## NOTES

We are glad to welcome again the Mexican Mining Journal. It remarks that "it is good to get mail every day instead of once in God-knows-when, as it was in the recent past." We learn from it that the first through train in two years from El Paso to Mexico City arrived in August, and that now mail, freight and passenger service have been resumed and are maintained on all railroad lines throughout Mexico.

According to an estimate by Sir John Murray, the total annual rainfall upon all the land of the globe amounts to 29,347.4 cubic miles,

and of this quantity 6,524 cubic miles drain off through rivers to the sea. A cubic mile of river water weighs, approximately, 4,205,650,000 tons, and carries in solution, on the average, about 420,000 tons of foreign matter. In all, about 2,735,000,000 tons of solid substances are thus carried annually to the ocean.

A heavy rainfall occurred in the Canal Zone near Gatun on August 12. The maximum fall for 1 hr., 3.45 p. m. to 4.45 p. m., at Gatun, amounted to 4.72 in. This hourly record has been exceeded but twice on the Isthmus since automatic records have been kept, namely, 5.86 in. in 1 hr., at Balboa on June 2, 1906, and 4.90 in. at Colon on Oct. 8, 1908. The heaviest fall on Aug. 12 occurred at Agua Clara reservoir, amounting to 7 in. in a little less than two hours.

A famous English firm that manufactures a large luxurious car, a well-known American firm manufacturing a cheap car, and a firm equally high in the light car world all employed the same ore for their cylinder castings. Questioned on the subject, the large car firm uses it "because it is the best," the American firm "because it is the cheapest," and the light car firm "because it is best and cheapest." The answer of the American firm is explained by the fact that with the best ore there is a smaller percentage of faulty castings which have to be scrapped.

A test is now being made of lighting the port of Montevideo with high-pressure incandescent gas lamps. A trial installation of four Keith lamps, each of 3,000 candlepower, has been put up by the Montivideo Gas Co. These lamps which are hung on iron columns some 20 feet high and placed along the asphalt way leading to Mole A, have two mantles each and are lighted by gas at a pressure of 2,030 to 2,540 millimeters (80 to 100 in.) of water (2.9 to 3.6 lb.). The mantles are inclosed in separate coverings of silica, which, besides having the advantage of being small, are not subject to damage or breakage, even if they become wet.

Power is now carried over the new line of the Nevada-California Power Co. from the generating plant in the Sierra Nevada mountains near Bishop to El Centro in the Imperial Valley, a distance of more than 400 miles.

This is the longest power line in the world, being almost twice as long as the transmission line of the Pacific Light & Power Co., to Los Angeles. At the opening the new line carried 2000 hp. of electric energy. It has a capacity of 10,000 hp. The greater part of the power will be used for irrigation pumping. Underneath the Imperial Valley lie inexhaustible supplies of water, which must be pumped to the top of the ground to be available.

The firm of Dunford & Elliot, Sheffield, England, has recently introduced a patented process for manufacturing hollow metal rods. By this process hollow steel bars from  $\frac{3}{4}$  in. to 3 ins. in diameter and 20 ft. long are produced by rolling from a drilled ingot. After the piece has been pierced it is packed with a kind of sand which is capable of resisting high temperatures. The hole is plugged at each end with metal plugs and the billet is then heated and submitted to repeated rollings until a bar of the required dimensions is produced. It appears that the packing material acts as a fluid or as an elastic mandrel, thus maintaining a hole through the bar. After elongation the core is removed by a special process.

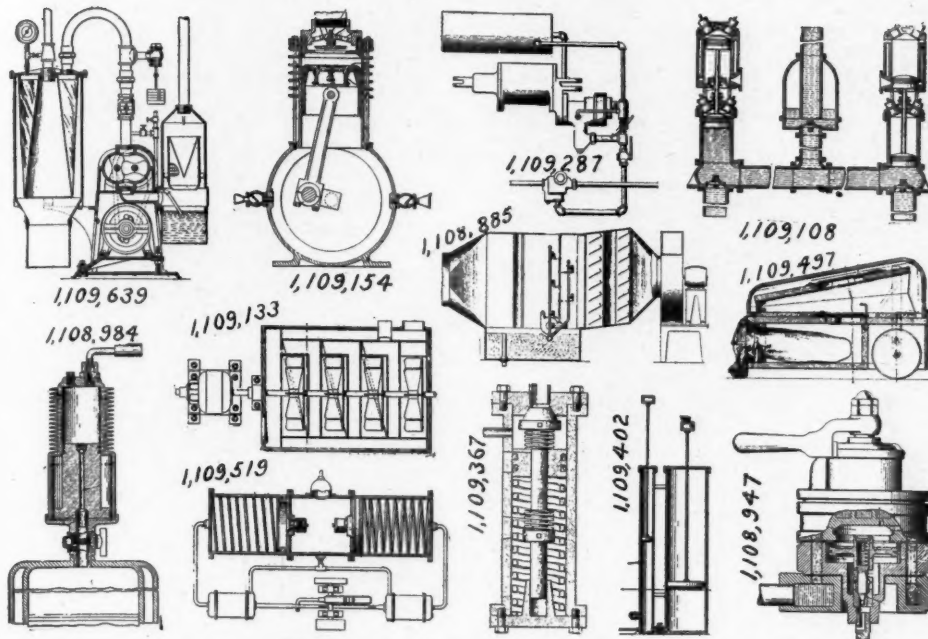
A medal to be known as the Franklin Medal, and to be awarded from time to time in recognition of the *total* contributions of individuals to science or to the application of physical science to industry, rather than in recognition of any single invention or discovery, however important, has been founded by Samuel Insull, Chicago, Ill., under the auspices and custody of the Franklin Institute. In founding this medal Mr. Insull has provided \$6000, of which \$1000 is to be used in securing appropriate designs and dies for the medal and diploma. The remaining \$5000 is to be held in trust in perpetuity, and the interest is to be used from time to time in awarding the medal. The intrinsic value of this is not to exceed \$75.

#### LATEST U. S. PATENTS

*Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.*

#### SEPTEMBER 1.

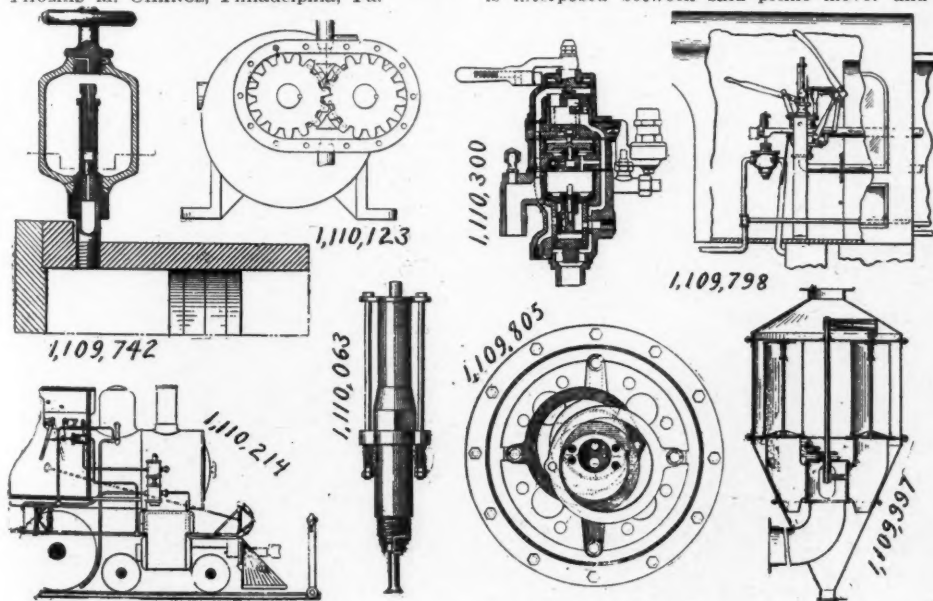
- 1,108,885. **SPRAYING MECHANISM**, ALLEN A. BLUMFELDT, Chicago, Ill.  
 1,108,930. **AIR-SPRING**, WILHELM L. OSTENDORF, Wilkins township, Allegheny county, Pa.  
 1,108,947. **FLUID-PRESSURE BRAKE**, WALTER V. TURNER, Edgewood, Pa.  
 1,108,952. **PNEUMATIC JACK**, NATHANIEL B. WALES, Saginaw, Mich.



## PNEUMATIC PATENTS SEPTEMBER 1.

- 1,108,984. APPARATUS FOR COMPRESSING AIR. HERBERT H. FREY, Chicago, Ill.  
 1,109,092. TRACK - SANDING APPARATUS. HARRY VISSERING, Chicago, Ill.  
 1,109,108. METHOD AND APPARATUS FOR PUMPING LIQUIDS. HENRY M. CHANCE and THOMAS M. CHANCE, Philadelphia, Pa.

1. A method of pumping liquid which consists in applying pressure, generated by the power impulse of a prime mover actuated by an elastic medium, to a confined body of liquid, a portion of which is interposed between an inlet for liquid and a region of discharge and a portion of which is interposed between said prime mover and a



## PNEUMATIC PATENTS SEPTEMBER 8.

second similar prime mover, in causing said pressure to commence the discharge of liquid at said region of discharge and simultaneously to cause said second prime mover to commence a return stroke thereof, in causing the movement of said second named portion of liquid after the completion of the power stroke of the first named prime mover to effect the completion of the return stroke of the second prime mover and simultaneously therewith to draw in a new increment of liquid.

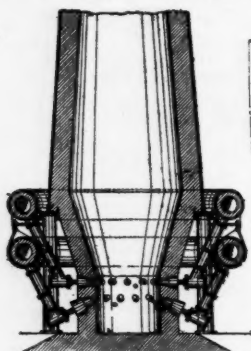
1,109,130. PNEUMATIC SOLE FOR SHOES.

EDGAR C. KAYE, Chicago, Ill.

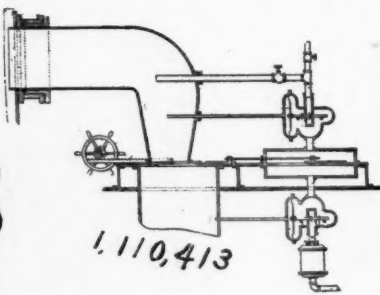
1,109,133. CENTRIFUGAL BLOWER. JOHN S. MELCHERS, New York, N. Y.

combination of a fuel chute in which the charge of fuel is to be seated; a fluid-pressure cylinder having an outlet port; a valve controlling said outlet port and having a stem provided with a collar that is adjustable longitudinally along said stem; a piston movable in the cylinder and having a central hole through which loosely passes that part of said valve-stem that is between the valve and the said collar; means to supply fluid-pressure to the cylinder to operate the piston, and a blast-pipe communicating from the said outlet port to the fuel chute.

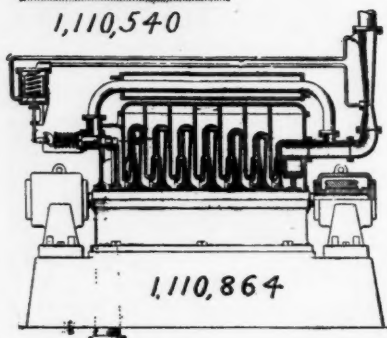
1,109,402. LUBRICATING DEVICE. ERNEST ODES COX, Wetumka, Okla.



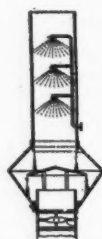
1,110,540



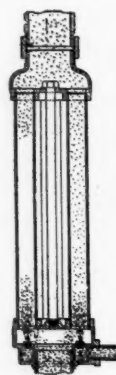
1,110,413



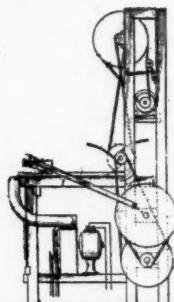
1,110,864



1,110,868

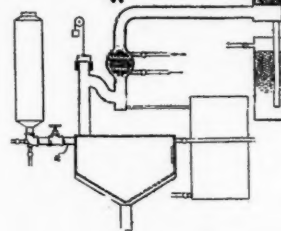


1,110,860



1,110,452

1,110,454



#### PNEUMATIC PATENTS SEPTEMBER 15.

1,109,146. PNEUMATIC VEHICLE-SPRING.

ROSS M. G. PHILLIPS, Harrison, N. J.

1,109,154. AIR-COMPRESSOR. JOHN H. THOMAS, Bloomfield, N. J.

1,109,171. AIR PURIFYING AND COOLING DEVICE. CARL F. LUNDEBERG, Hartford, Conn.

1,109,174. AIR-VALVE. CARL H. PETERSON, Hartford, Conn.

1,109,180. PNEUMATIC PLUG FOR HEELS. BENJAMIN ROSENBERG, New York, N. Y.

1,109,193. AERATING APPARATUS. OSCAR ZISTEL, Sandusky, Ohio.

1. Apparatus for transporting fish comprising in combination, a car and a water tank carried thereby, an air pump, connections for conducting air from the pump to the water within the tank, an electric motor for driving said pump, a storage battery, and means operated by the prime mover of the car for charging said battery.

1,109,287. AUTOMATIC RETAINER FOR AIR-BRAKES. JOHN O. HARRISON, Boone, Iowa.

1,109,367. FLUID-BLAST STOKER. JOSEPH M. SHULTS and FREDERICK W. SHULTS, Baltimore, Md.

2. A stoker for feeding fuel to furnaces by blasts of fluid under pressure, comprising the

1,109,419. PNEUMATIC PUMP. ANDREW J. HUBBARD and CARL A. SWANSON, Jacksonville, Ill.

1,109,492. COMBINED VACUUM-CLEANER AND CARPET-SWEEPER. MORRIS S. WRIGHT, Worcester, Mass.

1,109,497. APPARATUS FOR CLEANING CARPETS AND THE LIKE. MORRIS S. WRIGHT, Worcester, Mass.

1,109,519. AIR - COMPRESSING MACHINE. ALTON L. ELLIS, Eden, Miss.

1,109,639. VACUUM-CLEANER. WILLIAM S. SUTTON, Rockford, Ill.

#### SEPTEMBER 8.

1,109,714-5. FLUID-PRESSURE BRAKE. WALTER V. TURNER, Wilkesburg, Pa.

1,109,742. LUBRICATING DEVICE. WALTER S. EARLEY and ROBERT W. KILPATRICK, Philadelphia, Pa.

1,109,798. AUTOMATIC SAFETY DEVICE FOR LOCOMOTIVES. JAMES H. SMITH, Port Murry, N. J.

1,109,805. AIR COMPRESSOR OR MOTOR. WILLIAM A. WARMAN, New York, N. Y.

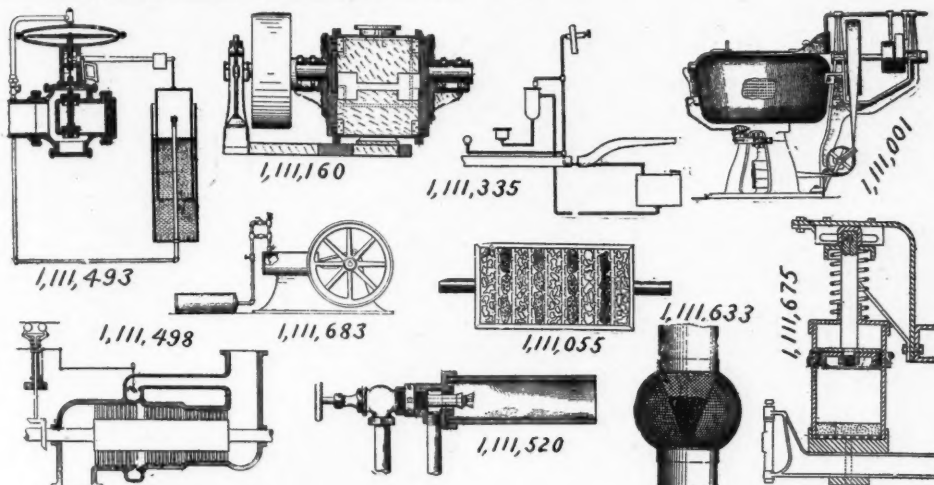
1,109,827. PNEUMATIC - DESPATCH - TUBE APPARATUS. MERTON L. EMERSON, Braintree, Mass.

- 1,109,997. AIR - PURIFYING APPARATUS. GUIDO E. LOB, Chicago, Ill.  
 1,110,063. PNEUMATIC TOOL. PAUL KOROK-NAY, Lyndora, Pa.  
 1,110,067. PNEUMATIC ENGINE OR TOOL. JOSEPH D. MACDONALD, Butte, Mont.  
 1,110,123. AIR-COMPRESSOR. ADOLPH F. FEL-  
 LER, Berkeley, Cal.  
 1,110,155. PNEUMATICALLY - OPERATED  
 PERCUSSIVE HAND-TOOL. CLEMENT HEN-  
 RY STEVENS, Las Palmas, Grand Canary, Can-  
 ary Islands.  
 1,110,214. AUTOMATIC TRAIN-STOP. WIL-  
 LIAM E. LAWN, Rochester, N. Y.  
 1,110,300-01. FLUID-PRESSURE BRAKE AP-  
 PARATUS. MURRAY CORRINGTON, New York,  
 N. Y.

SEPTEMBER 15.

- 1,110,364. PNEUMATICALLY - ACTUATED  
 MUSICAL INSTRUMENT. PETER WIGGEN,  
 Chicago, Ill.  
 1,110,413. APPARATUS FOR MEASURING  
 THE FLOW OF FLUIDS. THOMAS B. WYLIE,  
 Pittsburgh, Pa.

1. The method of measuring the volume of flow  
 of a fluid, which consists in causing it to flow



## PNEUMATIC PATENTS SEPTEMBER 22.

through a controllable opening, causing another  
 fluid to flow through another controllable open-  
 ing having its area definitely proportioned to the  
 area of the first named opening, maintaining a  
 difference in the pressures at opposite sides of  
 the last named opening which is proportional to  
 the difference in pressures at the opposite sides  
 of the first named opening, and measuring the  
 fluid which flows through the second opening;  
 substantially as described.

- 1,110,450. DUMPING - WAGON. CHARLES  
 MATTHEWS MANLY, Freeport, N. Y.  
 1,110,452. PLUME - DRYING APPARATUS.  
 HOMER METHOT, Red Bank, N. J.  
 1,110,454. RECLAIMING WASTE PRODUCTS  
 IN THE MANUFACTURE OF SULFITE  
 FIBER. HUGH K. MOORE and ROBERT B. WOLF,  
 Berlin, N. H.

3. The herein described process of recovering  
 sulfur dioxide, which consists in first filling an  
 open blow pit with steam to remove the air there-  
 from, then closing the pit and connecting the  
 same with an air pump, then discharging the  
 contents of a pulp digester into said pit, and con-  
 densing the vapors rising from the blow pit, and  
 recovering the uncondensed sulfur dioxide.

- 1,110,540. PROCESS OF SMELTING AND  
 PURIFYING IRON. GUSTAVE R. GEHRANDT,  
 Chicago, Ill.

1. The herein described process of producing  
 a purified iron which consists in smelting the ore,  
 collecting the smelted ore in the hearth of the  
 smelting furnace and in causing an air-blast to  
 enter the smelted iron and to enter and pierce  
 the same at an angle oblique to the level of the  
 smelted iron, said air-blast being passed through  
 the iron simultaneously as the supply of iron in  
 the hearth is replenished by freshly smelted iron  
 from above.

- 1,110,860. VACUUM - PRODUCER. CHARLES  
 HENRY ATKINS, Springfield, Mass.  
 1,110,864. CENTRIFUGAL COMPRESSOR.  
 OTTO BANNER, Easton, Pa.  
 1,110,868. ARRANGEMENT FOR PRECIPIT-  
 ATING DUST BY MEANS OF WATER.  
 GEORG J. BAUER, Frankfurt-on-the-Main, Ger-  
 many.

SEPTEMBER 22.

- 1,111,001. PNEUMATIC  
 LOCK FOR CENTRIFUGAL - EXTRACTOR  
 COVERS. WILLIAM BARTHOLOMEW and FRITZ  
 BALZER, Chicago, Ill.  
 1,111,055. PROCESS OF REGENERATING  
 AIR. HECTOR R. CARVETH, Niagara Falls, N.  
 Y.

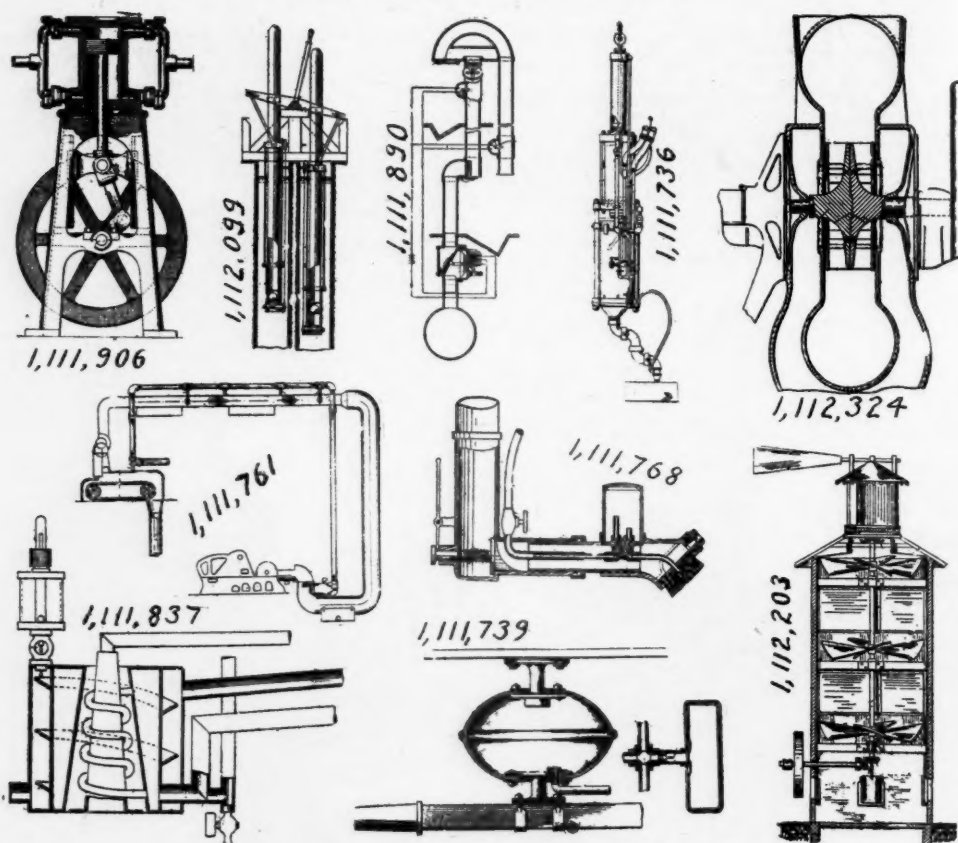
1. The process of regenerating air consisting  
 in passing the exhaled air in a closed circuit  
 first over a regenerating agent, then over a hy-  
 drating agent and then over a regenerating agent.

- 1,111,160. ROTARY BLOWER. BERTINIUS LAR-  
 SEN and WALTER H. PARKIN, Niles, Mich.  
 1,111,247. COMPOSITION FOR FORMING EX-  
 PLOSIVES WITH LIQUID OXYGEN.  
 GEORGES CLAUDE, Paris, France.

1. A composition for forming explosives with  
 liquid oxygen, comprising a combustible metallic  
 substance yielding by oxidation innocuous prod-  
 ucts of combustion, and a light inert substance  
 acting as a solid diluent, the amount of the me-  
 tallic substance in one liter of the composition be-  
 ing chemically equivalent to from one to six  
 hundred grams of powdered aluminium.

- 1,111,335. FUEL-OIL - DELIVERY SYSTEM  
 FOR MOTOR-VEHICLES. ALFRED E. WAL-  
 DEN, Detroit, Mich.

1. The combination with a main tank, of an  
 auxiliary tank at a higher level, a delivery con-  
 duit from said main tank to said auxiliary tank,  
 means for supplying air under pressure to said  
 main tank to elevate the oil therefrom to the  
 auxiliary tank, and means controlled by the level  
 of the oil in the auxiliary tank for regulating  
 the air pressure.



## PNEUMATIC PATENTS SEPTEMBER 29.

- 1,111,493. AUXILIARY REGULATING DEVICE FOR PRESSURE-REGULATORS. PETER J. QUINLAN, Marietta, Ohio.  
 1,111,498. TURBO-BLOWER. MAX ROTTER, Milwaukee, Wis.  
 1,111,520. OIL-BURNER. ARCHIE M. BAIRD and HARVEY D. PALMER, Topeka, Kans.  
 1,111,556. AUTOMATIC AIR-SUPPLY SYSTEM FOR AUTOMOBILES. WILLIAM C. BAKELS, Midland Park, N. J.  
 1,111,633. DUST-CATCHER FOR AIR-PIPES. JOHN W. YOUNG, Memphis, Tenn.  
 1,111,675. AUXILIARY PNEUMATIC SUPPORT FOR VEHICLES. PHILIP RAYSON, Elsternwick, Victoria, Australia.  
 1,111,683. STARTER FOR INTERNAL-COMBUSTION ENGINES. SIMON S. SUTTON, El-dorado, Ill.

## SEPTEMBER 29.

- 1,111,736. PROCESS OF FILLING MOLDS AND THE LIKE. IRA L. CONKLING, Philadelphia, Pa.  
 1,111,739. SHOCK-ABSORBER. BENJAMIN W. DAVIS, Phillips, Wis.  
 1,111,761. ART OF CLEANSING COTTON AND PREPARING IT FOR MARKET OR FOR CARDING. JOHN F. REARDON, Millville, N. J.

4. The herein described method of treating cotton and the like, which consists in conducting the cotton through a chamber or casing whose sides confine it against escape, and dispersing said cotton by discharging jets of compressed air against it.

- 1,111,768. CLEANING APPARATUS. IRA H. SPENCER, Hartford, Conn.  
 1,111,778. VALVE MECHANISM FOR PNEUMATIC PLAYERS. EUGENE T. TURNER, New York, N. Y.  
 1,111,837. HUMIDIFYING APPARATUS. ARTHUR R. JOYCE, New Fairfield, Conn.  
 1,111,890. PNEUMATIC - DESPATCH - TUBE APPARATUS. EDMOND A. FORDYCE, Boston, Mass.  
 1,111,906. AIR-PUMP AND VALVE THEREFOR. JESSE KEPPEL, St. Louis, Mo.  
 1,112,054. AIR-COMPRESSOR. LEROY CLAWSON, Hall, Mont.  
 1. A fluid compressing apparatus comprising axially aligned cylinders, pistons working in said cylinders, valves carried by the pistons, a piston rod common to said pistons, a check valve slidably mounted upon a rod between the pistons and in frictional engagement with the rod, and means on the cylinders to limit the movement of the check-valve.  
 1,112,066. GAS AND AIR MIXER. THOMAS H. HOLLIS, Pittsburgh, Pa.  
 1,112,099. BALANCED AUTOMATIC AIR-LIFT. NORMAN R. SMITH, Red Bluff, Cal.  
 1,112,203. ATMOSPHERIC POWER-GENERATOR. ALBERT J. FANDREY, Indianapolis, Ind.  
 1,112,324. IMPELLER FOR CENTRIFUGAL COMPRESSORS AND PUMPS. RICHARD H. RICE, Lynn, Mass.  
 1,112,334. PISTON FOR PNEUMATIC SMOKERS. BRUCE A. SHAW, Oak Park, Ill.  
 1,112,398. ROCK-DRILL. DANIEL S. WAUGH, Denver, Colo.